

NASA Technical Memorandum 103611

In-Flight and Simulated Aircraft Fuel Temperature Measurements

Roger Svehla
Lewis Research Center
Cleveland, Ohio

December 1990



(NASA-TM-103611) THE LANGLEY RESEARCH CENTER
AIRCRAFT FUEL TEMPERATURE MEASUREMENTS
(NASA) 103611

103611-1

103611-1
103611-1

NASA Technical Memorandum 103611

In-Flight and Simulated Aircraft Fuel Temperature Measurements

Roger Svehla
Lewis Research Center
Cleveland, Ohio

December 1990



(NASA-TN-103611) IN-FLIGHT AND SIMULATED
AIRCRAFT FUEL TEMPERATURE MEASUREMENTS
(NASA) 1991

103611

and 103

01/27/91 01/27/91

2

1000000

1000000

1000000

1000000

IN-FLIGHT AND SIMULATED AIRCRAFT FUEL TEMPERATURE MEASUREMENTS

Roger A. Svehla
National Aeronautics and Space Administration
Lewis Research Center
Cleveland, Ohio 44135

SUMMARY

The large increase in crude oil prices and the uncertain world supply, starting in 1973, prompted an effort to investigate the possibility of broadening jet fuel properties as a way of insuring a future supply. One property considered was the freezing point temperature; however, in-flight fuel temperature data for a realistic determination of acceptable freezing-point limits were generally unavailable. For this reason ten flights of an L1011 wide-bodied aircraft were conducted from April 23, 1981, to March 9, 1983, with a thermocouple rake installed in an inboard wing tank and another in an outboard tank. Temperature data were taken for both tanks, with one remaining full during the test period of either 2 or 5 hr. Test altitudes were initially about 10 700 m (35 000 ft), with an increase in altitude after the aircraft weight was reduced. Other data recorded were airspeed, air temperature, fuel quantity in each tank, and cabin fuel gauge temperature.

Temperature profiles generally developed in the expected manner. The bulk fuel was mixed by natural convection to a nearly uniform temperature, especially in the outboard tank, and a gradient existed at the bottom conduction zone. The data indicated that, when full, the upper surface of the inboard tank was wetted and the outboard tank was unwetted. A comparison was made of the single-point cabin fuel gauge reading and the research thermocouple temperatures. When fuel was withdrawn from the inboard tank, the data showed that the gauge usually agreed with the bulk temperature, or indicated a conservative temperature, lower than the bulk or minimum fuel temperatures. However, toward the end of one very long flight at low temperatures, the gauge temperature was slightly higher than the bulk and minimum temperatures. When fuel was withdrawn from the outboard tank, the outboard tank chilled faster than the gauge reading. This was probably due to the low fuel level. However, this is not cause for concern because it is not typical fuel-management procedure for commercial airplanes.

Fuel chilling tests were also conducted at the NASA Lewis Research Center in a 0.20 m³ (52 gal) tank simulator. It was chilled at the top and bottom, insulated on the sides, and had a vertical dimension 0.9 that of the L1011 outboard tank. Two long flights were simulated, one in warm air and one in cold air. Even though the simulator tank had no internal components, temperatures agreed with corresponding flight measurements for wetted upper surface simulator tests. Unwetted surface tests showed much slower heat-transfer rates. Tests were also run to compare results previously obtained with a simulator tank at Lockheed. Reasonable agreement of temperature profiles and unpumpable fuel were obtained, even though the Lockheed tank had internal components. It was concluded that if boundary conditions are carefully controlled simulators are a useful means of evaluating actual flight conditions.

Because favorable changes in fuel supplies and prices made high-freezing-point and other broadened-property fuels unnecessary, the research program was terminated prematurely. Additional testing had been planned. However, it is felt that the release of these data and discussions is of value for scientific and design reference.

INTRODUCTION

The large price increases and uncertain worldwide supply of petroleum in the period around 1973 to 1982 prompted many studies on the influence of jet fuel properties on cost and availability (refs. 1 to 9). One important property is the freezing-point temperature. (Fuels are a mixture of a large number of components. When the fuel is cooled, freezing occurs over a wide temperature range. The "freezing-point temperature" is the first observable evidence of solid formation as prescribed by the American Society of Testing and Materials test ASTM D-2386.) Higher freezing-temperature limits permit blending of heavier crude components into the jet fuel to increase refinery yields from both petroleum and possible alternative sources, such as coal and shale liquids (ref. 10). Present freezing-point temperatures are conservative limits, based on a safety margin below the low-probability, statistical minimum fuel temperatures for long range flights.

The practical acceptance of higher-freezing-point fuels requires the determination of two kinds of information. The first is the actual pumpability behavior of fuel near the freezing point. The second is the minimum fuel temperature and corresponding fuel temperature gradient.

A number of previous studies have been conducted to address the first kind, the determination of low-temperature pumpability. Fuel chilling tests used aircraft wing tank simulators that maintained internal fuel temperature gradients believed representative of those encountered in airplane flights (refs. 11 to 15). The simulators were rectangular-parallelepiped-aluminum tanks, chilled on the top and bottom, insulated on the sides, with internal components typical of aircraft wing tanks. These studies demonstrated that flowability is influenced by the fuel composition, recirculation, additives, and minimum fuel temperatures occurring near the simulator surfaces, temperatures considerably below the apparent bulk fuel temperatures (refs. 10, 12, 16, and 17). Tank vibration, sloshing, the use of ejectors, and the rate of fuel withdrawal had little effect on pumpability. Further studies have been made on the effectiveness of heating fuel within the tank in maintaining fuel pumpability at low bulk temperatures (refs. 18 to 20). Results have shown an expected improvement in pumpability compared to unheated fuel, but the heating methods were not successful in adequately heating the fuel boundary layer at the bottom of the tank.

For the second determination, studies have generally been based on statistical compilations of altitude - temporal temperature variations (refs. 21 to 23). Also, predicted fuel temperature profiles using a one-dimensional, unsteady-state, heat-transfer model have compared favorably with fuel tank simulator tests (refs. 17 and 24). A three-dimensional model for arbitrary geometry, and including freezing and thawing, has been applied to an external cylindrical fuel tank (refs. 17 and 25). However, comparison with in-flight data has been limited almost exclusively to single-point bulk-fuel temperatures

from the aircraft instrumentation. Only one example of internal temperature gradients has been reported, that from a 1967 test of an instrumented Boeing 707 reserve tank (ref. 26).

To provide an extensive, representative database of in-flight fuel temperatures, a flight test program was conducted to measure temperature profiles within the fuel tanks of a wide-bodied commercial aircraft. This is the size of aircraft used for long-range flights that have the longest cold-soak times. The flight data established a reference set of temperature histories that is useful for specifying conditions for simulator tests and for evaluating the validity of the simulator profiles.

This report is a summary of the flight data and a comparison with reference tests conducted in wing-tank simulators. The flight tests were conducted from 1981 to 1983 at the Lockheed-California air field at Palmdale, California. The simulator tests were conducted from 1981 to 1984 at the NASA Lewis Research Center and the Lockheed Rye Canyon Research Center (now the Kelly Johnson Research Center). The report presents tables and plots of the temperature and flight-parameter histories of four of the ten test flights and data from simulator tests simulating conditions of two of the flights. The data to evaluate the prediction of internal temperature gradients and the potential effects on fuel pumpability are discussed. A summary of preliminary flight results was presented at a 1983 conference (ref. 27). It has not been possible to publish the complete flight data and simulator comparisons until now, but it is felt that this report offers information to the public that is still timely and relevant.

FLIGHT TEST PROGRAM

The flight data were obtained under NASA Contract NAS3-22545 with Lockheed-California, using an L1011 research aircraft located at Palmdale, California. The program was designed to obtain wing tank vertical fuel temperature measurements at altitudes of at least 10 700 m (35 000 ft), where typical ambient temperatures are low. As shown in the aircraft sketch (fig. 1), one thermocouple rake was installed on an inboard tank and one rake was installed on an outboard tank on the opposite wing. Figure 2 is a photograph of the shorter rake, which was for the outboard tank. Figure 3 is a sketch of the same rake installed. (See appendix A for further discussion of the instrumentation.) The original program plan called for a total of eight 5-hr flights (a typical long flight) and twelve 2-hr flights. The shorter flights were intended to test the reproducibility of the data. During each flight one of the two instrumented tanks was to remain full, but the other could be undergoing fuel withdrawal. Half of the long flights and half of the short flights were to be flown with the inboard tank full, and the other flights with the outboard tank full. It would not have been possible to maintain both tanks full on the same flight because of aircraft stability problems. In either situation, data were recorded from both tanks starting from takeoff and continuing through descent. In addition to the fuel temperature profile, the data recorded were the static air temperature, Mach number, heading, fuel quantity in each tank, altitude, time, and the fuel temperature indicated in the cabin.

In order to avoid the high cost of dedicated flight hours, the program was designed to obtain data during flights of other research programs.

Because of the rather stringent flight constraints of the present program, only a few of the other scheduled research flights met these requirements. This resulted in data being obtained on an irregular basis. Early in 1982 Lockheed announced that L1011 production would be discontinued. With the elimination of L1011 production, the number of available research flights was even further reduced. At that time three 5-hr flights and five 2-hr flights had been completed. The opportunity for additional flights appeared unlikely, although another 2-hr flight was completed in August 1982. The lowest average static air temperature experienced up to that time was -51°C during the first flight. All other flights had average temperatures of about -46°C , although in some cases there were short periods when the temperature went below -50°C . It was felt that in order to get sufficient low-temperature data, it would be important to have one additional long flight with the outboard tank full. The program was modified to provide for one flight on a dedicated flight hour basis. Even though two of the three completed long flights were with the outboard tank full, there was a greater need for an additional outboard tank test, rather than another inboard test, for the following reasons. The outboard tank could be chilled to a lower temperature than could the inboard tank, but the first flight with the inboard tank full had the lowest air temperature of any flight. Cold-soaking the outboard tank would assure that for the two lowest temperature flights, one flight would be with the inboard tank full and the other with the outboard tank full. Also, the height of the outboard tank at the thermocouple location was about the same as the height of existing fuel tank simulators. Low-temperature data from the outboard tank would be useful for making comparisons with fuel tank simulator tests and results from computer modeling.

Appendix B gives a summary of the flight dates, flight times, and a short narrative description of each of the flights.

RESULTS OF FLIGHT DATA

The results are presented in figures 4 and 5 and in tables 1 to 12 for the four long flights. These were the ones which are most useful for analysis. The six short flights were flown in relatively warm air and did not provide sufficient low-temperature information. Figures 4(a) to (d) are plots for each flight of temperature versus time of the static and total temperature, lower surface temperature, and the temperature of the thermocouple nearest mid-height. Figures 5(a) to (d) show the wing temperature profile of each flight at various times during the test period. The tables are divided into four sets of data. The first set (tables 1 to 4) are the flight parameters (altitude, airspeed, and heading) and the ambient air temperature. The second set (tables 5 to 8) are the fuel quantities remaining in the tanks, the cabin indicated fuel temperature, and the flight engineer's comments. The third set (tables 9 to 12) are the thermocouple-measured fuel temperatures. The fourth set (tables 13 to 16) are again the minimum thermocouple-measured fuel temperature and the cabin indicated fuel temperature, along with the calculated bulk fuel temperature. Data from tables 5 to 12 were repeated in tables 13 to 16 for the purpose of comparing with the bulk fuel temperature.

DISCUSSION OF FLIGHT TESTS

Temperature Profiles

The temperature profiles in the tank develop by means of conduction and natural convection. At the top, conduction through the skin chills the top liquid surface, and natural convection starts transporting the cold, denser fluid toward the bottom. At the bottom, heat transfer is by conduction alone. The heat transfer rate in the liquid is controlled by the upper surface temperature. If ullage exists, the rate of heat transfer is significantly lower than if the upper surface were wetted, because of the insulating effect of the ullage vapor. Heat transfer at the bottom is much less whether or not ullage exists. The resulting vertical temperature profile shows a narrow gradient at the top, a broader conduction gradient at the bottom, and a wide mixing region caused by natural convection in the bulk of the fuel.

A comparison of flight data is difficult; ambient conditions cannot be controlled or duplicated, and a range of flight environments results. However, general observations are possible. Changes in air temperature are quickly reflected in the surface temperature but are damped out in the fuel, resulting in fairly smooth changes in the bulk temperature with time. This can be seen from the lower surface and midheight temperatures (fig. 4), in the temperature profiles (fig. 5), and in tables 13 to 16. The occasional abrupt changes in ambient conditions during cruise were due to altitude or climatic changes.

Figure 5(a) shows a narrow upper temperature gradient in the inboard tank, between the upper surface and the location of the thermocouple immediately below the surface. This indicates that either the inboard tank had a wetted upper surface or had ullage which did not exceed 1.3 cm (0.5 in.). In contrast, figures 5(b) to (d) show a broad upper temperature gradient in the outboard tank within the top 5 cm (2 in.), which indicates some ullage. With ullage, the upper surface would chill at a much faster rate than the bulk fuel because of the insulating effect of the ullage vapor. If the upper surface were wetted, the surface would be in contact with relatively warm fuel, as the chilled fuel is continually being transported to the bottom by natural convection. This would cause the upper surface to be relatively warm as compared to the lower surface. A comparison of the data between tanks shows that, when the inboard tank was full, the bottom surface was considerably colder than the top during flight; when the outboard tank was full, the top surface was slightly colder than the bottom during flight. This would suggest that the full inboard tank was wetted and the full outboard tank was unwetted. While clearly the outboard tank had ullage, it is not necessarily true that the full inboard tank was wetted. The ribs and stringers were wetted and could have provided a sufficient increase in the effective heat transfer area to compensate for an unwetted upper surface.

The temperature profiles of the outboard tank may be compared with data obtained from simulators at Lockheed and Boeing (refs. 11, 12, 16, and 28), which had vertical dimensions slightly less than the outboard tank at the thermocouple location. The profiles are in qualitative agreement and show a high degree of mixing. In contrast to the outboard tank, the temperature profiles of the inboard tank (fig. 5(a)) appear to show less mixing. The other flights with the inboard tank cold-soaked showed similar behavior. This difference in

that compares both situations was developed by Nield (ref. 29). For a wetted upper surface, buoyancy effects dominate and the results were expressed in terms of the Rayleigh number. For an unwetted surface, surface tension also becomes an important parameter and the results were expressed in terms of the Marangoni number. A calculation of the Rayleigh and Marangoni numbers indicates that both tanks were sufficiently in excess of the critical numbers necessary to promote natural convection. As shown by Nield, the two effects can reinforce each other. Thus, possibly the combined effects in the outboard tank were sufficiently greater than buoyancy alone in the inboard tank to more than compensate for an unwetted surface in the outboard tank. A third possibility is the influence of the relatively warm bulkhead near the thermocouple rake, inducing an additional means of heat transfer. Although an additional mode of heat transfer would be expected to increase mixing, a circulation pattern could develop and the shape of the temperature profile would change.

For the last flight on March 9, two thermocouples were added to the outside surface of the outboard tank, one on the top and one on the bottom. They were miniature Type K foil backed sensors cemented to the surface and covered with a moisture seal and fiber glass tape. This procedure was similar to that used for the surface thermocouples on the inside surface. The recorded temperatures from these outside thermocouples are included in table 12B. The data show consistent trends with the ambient and inside surface temperatures. However, the outside lower surface chilled more rapidly than the upper surface. After the first hour at cruise altitude, the outside lower surface temperature was as low as the total temperature and already considerably colder than the inside lower surface temperature. This indicated temperature gradient across the lower surface was much greater than that found by calculating a temperature gradient from the observed rate of change of the bulk fuel temperature. This temperature difference may have been due to the difference in location of the outside surface thermocouple and the thermocouple rake. A temperature difference could exist between the two locations. Another possibility is that the outside thermocouple measured an interface temperature rather than a true surface temperature. In contrast to the lower surface, the outside upper surface thermocouple appears too warm. The most likely explanation is solar radiation. Since the tape covering the outside thermocouples was dark, it would be a higher absorber of radiation than the aluminum surface. This would warm the outside thermocouple above the true surface temperature.

Comparisons To Cabin Temperature Gauge Readings

A comparison between the cabin recorded fuel temperature and the thermocouple data provides some interesting observations. The temperatures indicated on the gauge in the cabin are shown in tables 5 to 8. They were obtained from a resistance temperature detector located near the bottom of a surge box in outboard tank 2L. Outboard tank 2L is in the wing opposite the wing in which outboard tank 2R is located, the tank being cold-soaked. Graduation of the gauge is 5 °C, with an overall estimated uncertainty of about 2 °C. This estimate is a combination of the accuracy of the probe and of the parallax caused by the position of the gauge in the cabin. The gauge is a standard instrument in the cabin for an indication of the approach of the bulk fuel temperature to the specification freezing point temperature. If the gauge fuel temperature decreases to within a stated margin (usually 3 to 5 °C) of the

freezing point (-40°C for Jet A), corrective action is taken, such as a reduction in cruise altitude. This rare occurrence might happen during long flights at low ambient temperatures.

Tables 13 to 16 are a comparison of the minimum, bulk, and gauge temperatures of the four long test flights. The gauge-temperature indications are from tables 5 to 8 and the minimum temperatures are from tables 9 to 12. Data from both instrumented tanks are shown. The minimum temperatures are from the thermocouple in the fuel which had the lowest temperature. This would normally be the thermocouple immediately above the lower skin (0.6 cm). The bulk temperatures are a calculation of the mean liquid temperature, based on the temperature profiles of tables 9 to 12. For purposes of calculation, the vapor-liquid interface was assumed to be midway between the location of the thermocouple below the liquid fuel interface and the thermocouple immediately above. The interface was identified by a discernible break in the temperature profile. For the tank being cold-soaked, this location slowly moves downward as the density increases with cooling (ullage volume increases). For the other tank, the interface height decreases more rapidly with fuel withdrawal. During the April 23 flight, when fuel was withdrawn from the outboard tank, the fuel level soon became too low to make a meaningful calculation. At this point no further results are shown. The results for all the other cases were terminated at the end of the test period, just prior to descent.

During the flight of April 23, inboard tank 1 was cold-soaked and tanks 2R and 2L underwent fuel withdrawal at about equal rates. For the other long flights, inboard tanks 1 and 3 started out with about the same quantity of fuel and were depleted at about the same rate, while outboard tanks 2R and 2L both remained full. This would suggest that the gauge temperature from tank 2L and the bulk-fuel temperature obtained from the thermocouples in tank 2R should be the same. However, there were some differences between the two temperature sensors. The gauge sensor and thermocouple rake were in slightly different relative locations in each tank. The gauge sensor was enclosed in the tank 2L surge box, adjacent to the inboard tank 1 bulkhead, whereas the thermocouple rake was further outboard in tank 2R, away from the tank 3 bulkhead. Also, the sensor mountings were significantly different. The thermocouple rake was fabricated in a manner to completely immerse the thermocouples in the fuel (figs. 2 and 3). The gauge sensor was enclosed in a flanged sheath that was riveted to the tank wall. This would make the gauge sensor more sensitive than the thermocouples to the surface temperature and to the condition in the adjacent inboard tank. As a result, if fuel were being withdrawn from tank 1, the gauge-indicated temperature would be expected to respond more quickly to changes in the ambient temperature. If tank 1 were full, the rate of change of the gauge temperature would be moderated. This was in general agreement with the data.

On the ground before takeoff, as the air warmed in the morning, the surface warmed more quickly than the bulk fuel. In addition, sunlight radiation heated the upper surface, and exhaust from the idling engine may possibly have heated the lower surface. This would lead to a higher gauge-indicated temperature than bulk temperature, as the gauge sensor would respond more quickly to surface temperature changes. This was observed in the pre-flight of the data flights reported, and also in the data of the other flights not reported herein.

surface temperature changes. This was observed in the pre-flight of the data flights reported, and also in the data of the other flights not reported herein.

During ascent the ambient temperature decreased rapidly. When outboard tank 2R was cold-soaked, the gauge temperature decreased more rapidly than the bulk temperature. This was expected, since the gauge temperature would again be more sensitive to the rapidly changing surface temperature than would the bulk temperature. Eventually, after extended cold-soak time at cruise, the temperatures generally agreed. When inboard tank 1 was cold-soaked, the minimum temperature in inboard tank 1 and the bulk and minimum temperatures of outboard tank 2R were all lower than the gauge temperature. The low temperature in the outboard tank was probably a result of the low fuel level at the thermocouple rake.

During the last hour of cruise of the March 9 flight, the gauge temperature increased slightly after reaching the same temperature as the tank 2R bulk temperature. A possible explanation is the influence of tank 1, immediately adjacent to the gauge sensor. Even though fuel was being withdrawn from tank 1, the fuel in tank 1 was still warmer than in tank 2R. Consequently, it was possible that after sufficient cold-soaking, the only appreciable heat flux was from tank 1 to the fuel temperature sensor. This would explain how a slight warming of the gauge temperature could have occurred at the end of the cruise.

Thus, fuel management has a significant effect on the fuel-gauge indications relative to apparent fuel temperatures existing at the wing tanks. During the cruise time of the April 23 flight, fuel was withdrawn from tanks 2L, 2R, and 3 simultaneously (table 5). On the other long flights fuel was withdrawn only from tanks 1 and 3. The latter management corresponds to the realistic practice in commercial flights, where fuel is retained in the outboard tanks for stability and flight control. Thus, the operational gauge temperatures appear to give a reliable indication of the approach to the freezing point, if applied conservatively. Although this conclusion is based on the tests in a specific airplane, it is reasonable to assume it also applies to other types of wide-bodied aircraft with similar locations of fuel-temperature indicators and fuel tank configurations.

FUEL TANK SIMULATOR PROGRAM

Test Facility

Wing fuel tanks have large lateral dimensions compared with the vertical dimension. Heat transfer is dominated by flux in the vertical direction by means of conduction and natural convection. Existing fuel tank simulators model this situation by using a typical full-scale vertical dimension, shortened lateral dimensions, cooling on the top and bottom, and insulation on the sides.

The tank simulator used for the tests at the NASA Lewis Research Center was fabricated by the Lockheed-California Company. It was similar in design to the tank used by Lockheed for a series of tests at the Kelly Johnson Research Center (refs. 11, 12, and 16). The most significant difference

(20 in.) high for a total volume of 0.20 m^3 (52 gal). These dimensions were also very close to a third simulator tank at the Boeing Developmental Center (refs. 13 and 28).

The NASA tank was made of 6061-T6 aluminum alloy sheet with cooling provided on the top and bottom by means of panels. Each panel consisted of an embossed aluminum sheet spot-welded to the flat aluminum sheet of the top or bottom. The embossing formed a continuous "S" shape of parallel channels. The coolant was methanol, which was prechilled in an external storage tank by liquid nitrogen. The liquid nitrogen flowed through the storage tank inside a helical copper tube. The simulator tank with its external polyurethane insulation is shown in figure 6. The large square double-paned observation window with a nitrogen purge is seen in the front. The other three sides had smaller circular windows.

A small reservoir at the top of the simulator tank provided a source of fuel if a wetted upper surface were required during testing. Fuel flowed from the reservoir by gravity into the tank to compensate for the volume reduction during cooling, thereby maintaining a wetted surface.

Temperatures were obtained by means of five copper-constantan thermocouple rakes, one in each corner and one in the middle. Additional thermocouples were located on the side surfaces to verify the effectiveness of insulation. Also, thermocouples were located on the top and bottom surfaces to determine temperature uniformity and to provide a target temperature for the temperature controller.

The fuel was pumped out by means of a boost pump located below one corner of the tank into a 0.31 m^3 (83 gal) stainless steel weighing drum. Weighing was done by means of load cells. There were load cells under each corner of the tank and another under the weighing drum. For storage between tests, the fuel was pumped in another drum of the same size as the weighing drum.

Test Procedure

Prior to testing, the methanol was prechilled by starting the liquid nitrogen flow from the nitrogen storage dewar to the methanol storage tank. The methanol was then circulated through a circuit which bypassed the simulator tank. While the methanol was being chilled, the tank was filled with fuel. If a wetted upper surface were required, the reservoir was filled. By the time the tank was filled, the methanol was chilled and fuel cooling could begin.

First the fuel was brought to the initial test temperature. In most cases this involved a slow, controlled cooling so as not to overshoot the desired starting temperature. If the ambient fuel was below the desired initial test temperature, the methanol was heated by electrical heaters located in a bypass heating system.

During testing the methanol flow rate was controlled by a temperature controller in order to provide programmed temperature - time schedules independently for the top and bottom surfaces. Manual adjustments were made as needed. Data were recorded at 15-min intervals during the first few tests,

During testing the methanol flow rate was controlled by a temperature controller in order to provide programmed temperature - time schedules independently for the top and bottom surfaces. Manual adjustments were made as needed. Data were recorded at 15-min intervals during the first few tests, and then at 5-min intervals during all remaining tests. In addition to the thermocouple data, the other recorded data were nitrogen and methanol temperatures, pressures, and flow rates. After completion of the test, the fuel was pumped out and weighed. Remaining unpumpable fuel was warmed by either leaving it in the tank overnight or electrically heating the methanol. After warming, the remaining fuel was pumped out and weighed. A final weight was also taken.

Discussion of Test Parameters

The first tests were designed to simulate the conditions of selected outboard-tank cold-soak flights. Tests were conducted with Jet A fuel, the same commercial fuel used in the flight tests. The simulation was performed by programming the temperature controller to duplicate the measured upper and lower inside surface temperatures of the flights. The starting condition was during ascent, when the temperature profile was uniform. The outboard tank was chosen because the height at the thermocouple rake location of 56 cm (22 in.) was close to the simulator tank height of 51 cm (20 in.). The two flights used in the simulation, the flights of June 21 and March 9, were long flights at fairly steady ambient temperature and offered a comparison of warm and cold flight conditions. Corrected thermocouple data were not available during ascent of the March 9 flight because of a loss of the reference voltage (appendix B). However, the uncorrected data used as the starting profile would be expected to be in error by no more than about 2 °C.

Flight and simulator surface temperatures were compared to ascertain how well they matched. Variations in the nitrogen flow rate sometimes caused the methanol temperature in the storage tank to vary, making it difficult to maintain the programmed temperatures. Tests were repeated as needed until a good simulation was obtained. Figure 7 shows a typical plot of the simulator and flight data for the upper surface. The upper surface is the important one, because it is the source of natural convection which dominates the heat transfer. The flight data were plotted at 10-min intervals, and the simulator data were plotted at 5-min intervals. The data show good agreement, although the simulator temperature shows more oscillation than the flight data because of overshoot in the controller response.

A comparison of temperature versus height profiles of the simulator tank thermocouple rakes is a convenient way of evaluating uniformity of the cooling surfaces and the effectiveness of the insulation. Table 17 shows a comparison of the five rakes during chilldown of the March 9 flight with a wetted upper surface. Rakes A and B are in the front corners by the window in figure 6 and rakes D and E are in the rear corners behind rakes B and A, respectively. Rake C is in the center. The temperatures measured by rakes A, B, and C were in agreement. Rake D shows erratic behavior, which was caused by it being located above the drain connected to an uninsulated boost pump. Rake E was slightly warmer at the top and colder at the bottom as compared with rakes A, B, and C for most of the simulation. This appeared to be caused by nonuniform cooling at the top surface, where the top of the corner at rake E tended to be slightly warmer than elsewhere.

DISCUSSION OF RESULTS OF SIMULATOR TESTS

Comparison of Flight and Simulator Temperatures

For each flight, a simulator test was run with a wetted upper surface and another test with about 1 cm of ullage for comparison. Figures 8 and 9 show the profiles of the center rake for each of the two flight simulations for both wetted and unwetted upper surfaces each compared to the in-flight data. Previous results have shown a large reduction in overall heat transfer from the fuel to surfaces for an unwetted surface compared with a wetted surface (ref. 26). As discussed previously, natural convection is significantly reduced with ullage as vapor-layer conduction becomes a major part of the resistance to heat flux.

The flight data and wetted-upper-surface simulator data are in fair agreement for the June 12 flight (fig. 8(a)) and in good agreement for the March 9 flight (fig. 9(a)), both much better than for the corresponding unwetted-upper-surface simulator tests (figs. 8(b) and 9(b)). For both tests with the wetted surface, temperature profiles match at the end of the flight. Since the flight data suggest that the upper surface of outboard tank 2R was unwetted (figs. 5(b), (c), and (d)), it would have been expected that the flight data would more closely agree with the simulator data of the unwetted surface. This was clearly not the case. A contributing cause might be that some wetting occurred. The upper surface of the wing tank was air-foiled shaped and at an angle of attack, making partial wetting possible. Another possibility is the fin effect of the wing-tank ribs and stringers, especially the spanwise stringers. The flight temperature profiles indicate that the stringers were partially wetted, which would enhance heat transfer similar to upper surface wetting. This is also consistent with the observation that agreement with the simulator data was better for the March 9 flight data than for the June 21 data. From the temperature profiles and reported fuel quantities, it appears that there was slightly more fuel in outboard tank 2R on March 9 than on June 21. This would imply more wetting on March 9 as well.

Again, the differences between the simulator tank and the wing tank must be emphasized. The height of the simulator was 0.9 that of the wing tank at the thermocouple location. The simulator had no internal components and was mounted horizontally, whereas the wing tank had partial wetting of the stringers and was airfoil shaped and at an angle of attack. While the same specification Jet A fuel was used in the comparison tests, there could be small differences in the thermodynamic and transport properties among fuel batches. In spite of these differences, the ability to match test conditions for consistent results between flight and simulator data was encouraging.

The flight data were also simulated in an independent study with the 51-cm-high Boeing tank simulator, reported in references 17 and 28. The tests were run with a wetted upper surface. Bulk temperatures were obtained simulating the June 21 and March 9 flights, and temperature profiles for the June 21 flight. Computer simulations were also run for both flights. The Boeing simulator had internal components of stringers, a baffle, and a boost pump for the June 21 simulation (ref. 17). For the March 9 simulation (ref. 28), the boost pump and baffle were removed. The reported bulk temperatures were higher in the simulator than in the airplane by as much as 4 °C, which was a greater difference than was expected. One possibility is that the stringers may have

entrapped vapor, thereby generating ullage and preventing a total wetting of the upper surface. Nevertheless, there was qualitative agreement and fair quantitative agreement. Again, the experiments and computer predictions indicated that the simulation of flight data is feasible, although verifiable boundary conditions, which can be controlled, are critical for a meaningful comparison of data. In addition, the Boeing simulations provided the interesting result that superimposed motion and vibration in the simulator, representing airplane dynamics, have minor, if any, effects on the temperature profile or amount of unpumpable fuel (ref. 28).

Comparison of Tests with Unpumpable Fuel

Additional tests compared the results from the NASA simulator with results from the Lockheed simulator at the Kelly Johnson Research Center. Since the two tanks are identical in overall dimensions, cooling surfaces, and insulation, a repeat of tests completed at Lockheed might give an indication as to the reproducibility of results between tank simulators at different laboratories. This would provide additional insight as to the reliability of fuel tank simulators in predicting in-flight fuel temperatures. There were some differences which affect a direct comparison of results. The simulator at Lockheed contained internal components, such as stringers and a surge box, and was mounted at a 4° angle to simulate the airplane wing dihedral, whereas the NASA tank had no internal components and was horizontal. In the tests at Lockheed, the vent tube was filled to provide a reserve so that the tank would stay filled during chilldown. It was later found that the reserve in the vent tube was insufficient to maintain a full tank. There was no obvious way to match this condition with the NASA tank. As an approximation, the NASA tank was filled but the reservoir was left empty, so that ullage would start soon after chilldown began.

The Lockheed tests (ref. 30) were designed to produce frozen, unpumpable fuel and examine the behavior at extreme low temperatures. The two flight simulations selected from the Lockheed tests for comparison were long, cold-soak tests, without heating or recirculation, which produced significant amounts of unpumpable fuel, or holdup, as it is sometimes called. The tests used a reference fuel designated LFP 14, a kerosene blend meeting all Jet A specifications other than freezing point temperature. The freezing point was -33 °C, which was above the -40 °C Jet A specification limit. The same fuel was obtained for the NASA simulator tests.

The flight simulations were 4 and 6 hr long. Two tests were made at NASA of the 6-hr simulation and one of the 4-hr simulation. Comparisons of the temperature profiles are shown in figures 10(a) and (b). The results shown in figure 10(a) were for the test which had the better temperature control.

Some observations can be made from the temperature profiles. Both figures show the bottom 10 cm of the Lockheed simulator chilled faster. Above the stringers in the bulk of the fuel, the temperatures more closely match for the 6-hr test than for the 4-hr test. In the 4-hr test the Lockheed simulator chilled slightly faster, especially early in the test. This was expected. The Lockheed simulator had stringers, which increased the effective surface area, and thereby increased the heat transfer rate.

Holdup for the test in figure 10(a) was 19.1 percent of the total fuel mass and for the other 6-hr test was 18.2 percent, as compared with 16.77 percent at Lockheed. The holdup from the 4-hr test was 4.5 percent as compared with 7.19 percent at Lockheed. The temperature at the bottom has an important impact on holdup. With the bottom chilling faster in the Lockheed simulator it would be expected that the holdup would be greater. This was true for the 4-hr test but not for the 6-hr test. However, previous tests (ref. 12) have shown that under conditions of holdup greater than 10 percent the buildup of solids impedes the liquid drainage nonuniformly, and reproducibility of otherwise similar test conditions becomes poor. If one allows for these experimental effects, the differences in the tank's internal configurations, and the inability to accurately establish comparable test starting conditions, the temperature profiles and holdup in the two simulators are in acceptable agreement.

CONCLUDING REMARKS

Because favorable changes in the fuel supply and price situation made high-freezing-point and other broadened-property fuels unnecessary, the research program was terminated prematurely. Additional testing with the fuel simulator would have been desirable. Tests to acquire further generic data comparing temperatures in the empty-tank configuration with those measured with the addition of internal components such as stringers, a surge box, or ejectors were planned. Nevertheless, this study has provided information of permanent value on the temperature characteristics of fuel stored in aircraft wing tanks during flight.

As has been observed by others, the impact on the rate of heat transfer by the presence of wing-tank ullage has been reaffirmed. The amount and location of wetted area is critical. While it is difficult to obtain this information during flight, skillful use of simulator tests can substitute for in-flight data.

The data of these tests show a good correspondence of the in-flight and simulator temperature profiles, particularly for tests where the upper surface of the simulator is clearly wetted. Comparisons of fuel-chilling behavior in two separate simulators, at NASA and at Lockheed, show some discrepancies in the temperature profiles. However, there was good qualitative agreement in the temperature trends and in the fraction of unpumpable fuel at extreme conditions. Certainly, the success of these difficult comparisons between independent facilities with some differences in internal configurations encourages the use of wing-tank simulators to predict in-flight fuel temperature and flow behavior.

APPENDIX A

THERMOCOUPLE INSTRUMENTATION

The wing tank and thermocouple locations on the L1001 test aircraft are shown in figure 1. Inboard tank number 1 with a nominal capacity of 24 500 kg (54 100 lb) and outboard tank number 2R with a nominal capacity of 11 700 kg (25 700 lb) were instrumented with one vertical thermocouple rake in each tank. The inboard tank had a 117 cm (46 in.) vertical rake with 21 thermocouples located 5.11 m (16.75 ft) from the wing leading edge measured along the aircraft axis. The outboard tank consists of two compartments with the rake being located in the inboard compartment. It was a 56 cm (22 in.) vertical rake with 15 thermocouples located 2.36 m (7.75 ft) from the leading edge. The outboard thermocouple rake assembly is shown in figures 2 and 3. Figure 3 shows the thermocouple locations measured from the lower skin surface, the same identification used in the columns of tables 9 to 12. The rake was an L-shaped aluminum support, 0.32 cm (0.125 in.) thick and 2.5 cm (1 in.) wide. The rake was attached to the upper and lower stringers, which are the internal spanwise stiffeners of the wing. The thermocouples closest to the surfaces were mounted on gusset plates attached to the rake. The central thermocouples were mounted directly to the rake support, oriented at right angles to the near-surface thermocouples. The inboard tank rake assembly is similar except that there are more thermocouples on the L-shaped support to accommodate the deeper tank at the inboard location.

The rakes were fabricated utilizing premium grade Chromel-Alumel thermocouple wire. The thermocouple wires were routed through gland penetrations in the fuel tanks, then terminated in Chromel-Alumel connectors. Premium grade Chromel-Alumel thermocouple wires were used to conduct the temperature signals to the signal conditioning equipment in the aircraft data center. Data were recorded on a 14-track magnetic tape.

Accuracy, stability, and repeatability were regularly monitored. Selected channels were periodically calibrated and two channels were continually monitored with an ice bath reference and a 1.0000-V reference signal. Overall system accuracy was believed by Lockheed to be within ± 1 °C.

APPENDIX B

SUMMARY OF L1001 AIRCRAFT FLIGHTS

The flights of the L1011 aircraft are summarized as follows:

Date	Full tank	Cruise time	Total flight time
April 23, 1981	Inboard	4 hr 28 min	7 hr 12 min
April 30, 1981	Outboard	5 hr 02 min	6 hr 44 min
June 21, 1981	Outboard	5 hr 00 min	6 hr 23 min
July 01, 1981	Outboard	3 hr 02 min	4 hr 01 min
August 01, 1981	Outboard	1 hr 59 min	5 hr 18 min
August 26, 1981	Inboard	2 hr 05 min	3 hr 29 min
August 27, 1981	Inboard	2 hr 02 min	3 hr 30 min
August 28, 1981	Inboard	2 hr 01 min	2 hr 52 min
August 18, 1982	Outboard	2 hr 06 min	3 hr 30 min
March 09, 1983	Outboard	6 hr 16 min	7 hr 40 min

Data were taken during the entire flight. The cruise time shown is the time flown at constant altitude with the test tank full. Other tests were often being run on the same flight, so that in some cases the total flight time was considerably in excess of the cruise time. The landing time on the August 18 flight was not recorded and the total flight time shown is an estimate.

It was expected that during the 5-hr cruise flights a steady-state temperature distribution might develop in the outboard tank, but probably not in the inboard tank. The 2-hr flights were to determine repeatability of the measurements and show the effect of different air temperatures. Unfortunately, until the final flight, all of the flights occurred when the air temperatures were relatively warm. In order to subject the fuel tanks to a colder environment during flight, the aircraft went to a higher altitude later in the flight when the quantity of fuel consumed reduced the weight sufficiently to permit an increase in altitude. The change was usually from 10 700 to 11 300 m (35 000 to 37 000 ft) and sometimes 11 900 m (39 000 ft). The only flight below 10 700 m was on June 21, when most of the flight was at 10 100 m (33 000 ft) due to air traffic controller constraints. A brief summary of each flight is now given.

April 23, 1981

The flight departed from and returned to Palmdale, California. The objective was to obtain 5 hr at cruise with the inboard tank full. The time at cruise was limited to 4.5 hr due to low fuel. The inboard tank was full until the end of the cruise, at which time redistribution of the fuel was initiated in preparation for landing. Data were taken for 7.5 hr.

April 30, 1981

The flight departed from and returned to Palmdale, California. The objective to obtain 5 hr at cruise with the outboard tank full was met. The cruise

was at 10 700 m for 2.8 hr and 11 300 m for 2.0 hr. At that time redistribution of the fuel was initiated in preparation for landing. The flight made several passes through a frontal system as evidenced by fluctuations in the ambient static air temperature. Data were taken for 7.2 hr.

June 21, 1981

The flight departed from Palmdale, California, and landed at Atlantic City, New Jersey, with routing over Miami, Florida, to extend the cruise time. The objective to obtain 5 hr at cruise with the outboard tank full was met. The flight was limited to 10 100 m for 3.3 hr due to aircraft performance and air traffic controller constraints. For the last 1.5 hr the altitude was 11 300 m. At that time redistribution of the fuel was initiated in preparation for landing. Data were taken for 6.7 hr.

July 1, 1981

The flight departed from Cleveland, Ohio, and landed at Palmdale, California. The objective to obtain 2 hr at cruise with the outboard tank full was exceeded by 1 hr. The thermocouple on the lower skin of the inboard tank failed at the start of the flight and a spare thermocouple was substituted at 1035. The entire cruise was at 10 700 m. After completion of the cruise redistribution of the fuel was initiated in preparation for landing. Data were taken for 4.3 hr.

August 1, 1981

The flight departed from and returned to Palmdale, California. The objective to obtain 2 hr at cruise with the outboard tank full was met. The cruise was at 10 700 m for the entire test period, except for the last few minutes when the altitude approached 11 900 m. At that time redistribution of the fuel was initiated in preparation for landing. Data were taken for 6.5 hr.

August 26, 1981

The flight departed from and returned to Palmdale, California. The objective to obtain 2 hr at cruise with the inboard tank full was met. The first half of the cruise was at 10 700 m and the second half was at 11 300 m. At that time redistribution of the fuel was initiated in preparation for landing. Data were taken for 3.7 hr.

August 27, 1981

The flight departed from and returned to Palmdale, California. The objective to obtain 2 hr of cruise with the inboard tank full was met. The first half of the cruise was at 10 700 m and the second half was at increasing altitudes of 11 300 and 11 900 m. At that time redistribution of the fuel was initiated in preparation for landing. Data were taken for 3.8 hr.

August 28, 1981

The flight departed from and returned to Palmdale, California. The objective to obtain 2 hr of cruise with the inboard tank full was met. Just over half the cruise was at 10 700 m and the remainder was at 11 300 m. At that time redistribution of the fuel was initiated in preparation for landing. Data were taken for 3.1 hr.

August 18, 1982

The flight departed from and returned to Palmdale, California. The objective to obtain 2 hr at cruise with the outboard tank full was met. The first half of the cruise was at 10 700 m and the second half was at 11 300 m. Data were taken for 2.9 hr.

March 9, 1983

The flight departed from and returned to Palmdale, California. The objective to obtain 5 hr at cruise with the outboard tank full was met. External thermocouples were mounted on the outboard tank at the location of the thermocouple rakes to obtain temperature gradients across the skin. Whereas previous flights had been in warmer air of the United States and Mexico, this flight took a northerly route into Canada in order to reach colder air. The first part of the cruise was at 10 700 m with an early increase to 11 200 m and then to 11 900 m. Some warmer air was encountered, so the altitude was decreased to 11 200 m to locate colder air, and finally up again to 11 900 m. After completion of the cruise, fuel redistribution was initiated in preparation for landing. Data were obtained for 8.5 hr, although some of the temperature data recorded on the computer at the start of the flight were lost. Data were also recorded onboard but they did not include the reference voltages needed to correct the onboard temperature data. The lost data all occurred before the cruise started, which left a reportable total data acquisition time of 7.5 hr.

REFERENCES

1. Robertson, A.G.; and Williams, R.E.: Jet Fuel Specifications: The Need for Change. Shell Aviation News, no. 435, 1976, pp. 10-13.
2. Dukek, W.G.; and Longwell, J.P.: Alternative Hydrocarbon Fuels for Aviation. Exxon Air World, vol. 29, no. 4, 1977, pp. 92-96.
3. Thomas, Ivor: Broadened Jet Fuel Specifications: Their Effect Upon Commercial Airplane Design and Operation. Shell Aviation News, no. 450, 1978, pp. 32-35.
4. Churchill, A.V.; Delaney, C.L., and Lander, H.R.: Future Aviation Turbine Fuels. J. Aircraft, vol. 15, no. 11, Nov. 1978, pp. 731-734.
5. Longwell, J.P.; and Grobman, J.: Alternative Aircraft Fuels. J. Eng. Power, vol. 101, no. 1, Jan. 1979, pp. 155-161.

6. Lewis, A.: Future Aviation Fuels - The Petroleum Industry Responds to the Challenge. SAE Paper 800769, May 1980.
7. Strauss, K.H.: Future U.S. Jet Fuels - A Refiner's Viewpoint. J. Energy, vol. 7, no. 3, May-June 1983, pp. 200-203.
8. Breton, T.R.; and Dunbar D.N.: Computer Analysis of Effects of Altering Jet Fuel Properties on Refinery Costs and Yields. NASA CR-174642, 1984.
9. Varga, G.M., Jr., et al.: Jet Fuel Property Changes and Their Effect on Producibility and Cost in the U.S., Canada, and Europe. (RL-1PD-85. Exxon Research and Engineering Co.; NASA Contract NAS3-22769), NASA CR-174840, 1985.
10. Friedman, R.: High-Freezing-Point Fuels Used for Aviation Turbine Engines. ASME paper 79-GT-141, Mar. 1979.
11. Stockemer, F.J.: Experimental Study of Low Temperature Behavior of Aviation Turbine Fuels in a Wing Tank Model NASA CR-159615, 1979.
12. Friedman, R.; and Stockemer, F.J.: Temperature and Flow Measurements on Near-Freezing Aviation Fuels in a Wing-Tank Model. ASME paper 80-GT-63, Mar. 1980.
13. McConnell, P.M., et al.: Fuel/Engine/Airframe Trade-Off Study: Operational Effects of Increased Freeze Point Fuels. AFWAL-TR-82-2067, Aug. 1982 (Avail. NTIS, AD-A121688).
14. Low Temperature Behavior of Fuels in Simulated Aircraft Tanks. Coordinating Research Council, Inc., CRC-532, May 1983 (Avail. NTIS, AD-A130267).
15. Kamin, R.A.; and McConnell, P.M.: Impact of Higher Freeze Point Fuels on Naval Aircraft Operations. ASME Paper 86-GT-262, June 1986.
16. Stockemer, F.J.: Low Temperature Fuel Behavior Studies. Aircraft Research and Technology for Future Fuels, NASA CP-2146, 1980, pp. 221-233.
17. Desmarais, L.A.; and Tolle, F.F.: Fuel Freeze Point Investigations. AFWAL-TR-84-2049, July 1984 (Avail. NTIS, AD-A152801).
18. Pasion, A.J.: Design and Evaluation of Aircraft Heat Source Systems for Use with High-Freezing Point Fuels. NASA CR-159568, 1979.
19. Friedman, R.; and Stockemer, F.J.: Experiments on Fuel Heating for Commercial Aircraft. AIAA Paper 82-1234, June 1982 (Also, NASA TM-82878).
20. Friedman, R.; and Stockemer, F.J.: Heating Experiments for Flowability Improvement of Near-Freezing Aviation Fuel. J. Aircraft, vol. 21, no. 4, Apr. 1984, pp. 250-255.
21. Pasion, A.J.: In-flight Fuel Tank Temperature Survey Data. NASA CR-159569, 1979.

22. Nastrom, G.D.; and Jasperson, W.H.: Flight Summaries and Temperature Climatology at Airliner Cruise Altitudes from GASP Data. NASA CP-168106, 1983.
23. Jasperson, W.H.; and Nastrom, G.D.: Temperature Histories of Commercial Flights at Severe Conditions from GASP Data. NASA CR-168247, 1983.
24. McConnell, P.M., et al.: Heat Transfer in Airplane Fuel Tanks at Low Temperatures. ASME Paper 83-HT-102, July 1983.
25. McConnell, P.M.: Development and Use of a Fuel Tank Fluids Characteristics Mathematics Model. NACP-PE-142C, Naval Air Propulsion Center, Jan. 1987.
26. Tolle, F.F: High-Freezing-Point Fuel Studies. Aircraft Research and Technology for Future Fuels. NASA CP-2146, 1980, pp. 205-219.
27. Svehla, R.: In-flight Atmospheric and Fuel Tank Temperature Measurements. Assessment of Alternative Aircraft Fuels, NASA CP-2307, 1984, pp. 131-139.
28. Mehta, H.K.; and Armstrong, R.S.: Detailed Studies of Aviation Fuel Flowability. NASA CR-174938, 1985.
29. Nield, D.A.: Surface Tension and Buoyancy Effects in Cellular Convection. J. Fluid Mech., vol. 19, part 3, July 1964, pp. 341-352.
30. Stockemer, F.J.; and Deane, R.L.: Additional Experiments on Flowability Improvements of Aviation Fuels at Low Temperatures. NASA CR-167912, 1982.

TABLE 1

FLIGHT PARAMETERS - TANK 1 COLD SOAK

APRIL 23, 1981

TIME PDT	ALTITUDE		AIRSPEED			AIR TEMP, C		HEADING DEG
	FEET	METERS	KNOTS	M/S	MACH	STATIC	TOTAL	
9:00	2456	748	13.7	7.1	0.020	24.5	24.5	3.2
9:10	2450	747	15.1	7.8	.022	24.6	24.6	43.9
9:20	8623	2628	256.8	132.8	.392	9.6	18.3	144.5
9:30	10077	3071	266.6	137.3	.409	6.8	16.2	208.8
9:40	15049	4587	370.7	190.8	.579	-3.2	14.9	210.4
9:50	20897	6369	414.3	213.3	.665	-17.3	5.3	150.4
10:00	27863	8492	457.4	235.4	.760	-34.8	-7.2	152.8
10:10	34035	10373	479.1	246.6	.821	-49.0	-18.8	139.8
10:20	34992	10665	480.1	247.1	.828	-51.7	-21.3	140.0
10:30	34964	10656	492.9	253.7	.852	-52.8	-20.8	88.9
10:40	34965	10657	493.5	254.0	.852	-52.2	-20.1	116.7
10:50	34972	10659	490.4	252.5	.846	-51.8	-20.1	116.6
11:00	34990	10665	486.4	250.4	.838	-51.5	-20.4	135.0
11:10	34968	10658	496.8	255.7	.847	-46.9	-14.3	124.6
11:20	34978	10661	490.8	252.7	.840	-48.1	-16.4	124.6
11:30	35003	10668	475.9	245.0	.815	-48.5	-18.7	304.4
11:40	34997	10667	482.4	248.3	.823	-47.1	-16.4	304.3
11:50	34976	10660	487.6	251.0	.836	-48.9	-17.6	294.8
12:00	35093	10696	463.4	238.6	.800	-52.1	-23.8	294.5
12:10	34991	10665	475.5	244.8	.820	-51.8	-22.1	307.6
12:20	35079	10692	470.0	241.9	.811	-52.1	-23.0	280.7
12:30	34976	10660	484.7	249.5	.839	-53.4	-22.5	305.7
12:40	35004	10669	484.6	249.4	.835	-51.2	-20.3	258.8
12:50	34988	10664	483.7	249.0	.832	-50.8	-20.0	250.1
13:00	34974	10659	477.5	245.8	.823	-51.5	-21.5	249.3
13:10	35018	10673	472.9	243.5	.815	-51.5	-22.1	142.4
13:20	34978	10661	479.3	246.7	.826	-51.5	-21.2	52.3
13:30	35263	10748	446.1	229.6	.769	-51.6	-25.4	89.9
13:40	35036	10678	441.2	227.1	.760	-51.3	-25.6	89.9
13:50	35028	10676	449.4	231.3	.774	-50.9	-24.3	250.9
14:00	35018	10673	450.5	231.9	.776	-51.0	-24.3	271.7
14:10	35028	10676	449.4	231.3	.774	-51.1	-24.5	13.5
14:20	35026	10676	448.8	231.0	.774	-51.7	-25.2	5.2
14:30	35038	10679	439.2	226.1	.757	-51.6	-26.2	327.9
14:40	35032	10677	439.0	226.0	.757	-51.8	-26.5	328.1
14:50	22165	6756	396.5	204.1	.640	-20.7	0.0	193.1
15:00	9044	2756	287.3	147.9	.440	7.9	18.8	329.0
15:10	12044	3671	196.0	100.9	.302	4.5	9.6	329.4
15:20	8937	2724	187.2	96.4	.286	8.9	13.5	13.0
15:30	9017	2748	343.7	176.9	.526	7.9	23.4	154.8
15:40	10233	3119	234.4	120.6	.359	7.2	14.5	313.0
15:50	9082	2768	280.4	144.4	.429	8.4	18.8	30.7
16:00	9478	2889	269.6	138.8	.413	8.0	17.6	21.6
16:10	9493	2893	292.8	150.7	.449	7.2	18.5	318.9
16:20	4326	1318	176.0	90.6	.263	21.7	25.8	53.9
16:30	2500	762	22.3	11.5	.033	27.1	27.2	213.7

TABLE 2

FLIGHT PARAMETERS - TANK 2R COLD SOAK

APRIL 30, 1981

TIME PDT	ALTITUDE		KNOTS	AIRSPEED		AIR TEMP, C		HEADING DEG
	FEET	METERS		M/S	MACH	STATIC	TOTAL	
8:40	2490	759	19.4	10.0	0.029	26.1	26.1	171.6
8:50	2464	751	12.3	6.3	.018	27.2	27.2	3.5
9:00	6074	1851	261.9	134.8	.394	18.5	27.5	204.5
9:10	9456	2882	272.9	140.5	.417	9.4	19.2	134.4
9:20	14761	4499	399.3	205.5	.627	-6.1	14.8	209.7
9:30	24650	7513	460.7	237.1	.752	-26.2	1.7	146.1
9:40	29431	8970	490.9	252.7	.821	-37.4	-5.6	146.0
9:50	34738	10588	476.5	245.3	.813	-46.9	-17.0	146.0
10:00	35015	10672	472.7	243.3	.801	-44.0	-14.6	146.2
10:10	35017	10673	469.8	241.8	.792	-41.6	-12.5	146.2
10:20	35036	10678	460.5	237.1	.773	-39.7	-11.8	20.9
10:30	34999	10667	483.9	249.1	.811	-39.0	-8.2	20.7
10:40	35018	10673	471.4	242.7	.797	-42.6	-13.3	235.1
10:50	35010	10671	472.4	243.2	.796	-41.4	-12.0	230.3
11:00	34997	10667	482.6	248.4	.818	-43.7	-13.0	230.3
11:10	34989	10664	483.5	248.9	.823	-45.7	-15.0	230.2
11:20	35019	10673	470.9	242.4	.804	-47.5	-18.3	230.3
11:30	35015	10672	469.0	241.4	.802	-47.9	-18.9	71.7
11:40	34992	10665	474.6	244.3	.812	-47.9	-18.2	44.7
11:50	35000	10667	475.6	244.8	.810	-46.0	-16.2	45.0
12:00	35016	10672	466.4	240.1	.790	-43.7	-15.1	44.8
12:10	35009	10670	477.7	245.9	.804	-40.8	-10.7	45.0
12:20	34999	10667	480.0	247.1	.806	-39.8	-9.5	44.9
12:30	35022	10674	468.2	241.0	.789	-40.9	-12.1	240.0
12:40	34998	10667	480.8	247.5	.811	-41.5	-11.0	240.2
12:50	36626	11163	456.0	234.7	.779	-47.2	-19.8	240.0
13:00	37013	11281	452.3	232.3	.778	-50.7	-23.7	240.2
13:10	36980	11271	479.7	247.0	.828	-52.0	-21.7	240.2
13:20	37007	11279	460.0	236.8	.794	-52.0	-24.2	25.2
13:30	37003	11278	459.2	236.4	.794	-52.6	-24.8	24.8
13:40	36993	11275	467.1	240.5	.803	-50.5	-21.7	65.8
13:50	37005	11278	472.5	243.2	.807	-47.2	-17.8	69.0
14:00	37006	11279	472.1	243.0	.799	-43.3	-13.9	68.9
14:10	37004	11278	476.0	245.1	.806	-43.4	-13.6	211.7
14:20	36972	11268	480.5	247.3	.816	-44.6	-14.2	278.1
14:30	36956	11264	486.1	250.2	.834	-49.5	-18.4	283.7
14:40	36970	11268	476.0	245.0	.823	-53.0	-23.1	329.8
14:50	36996	11276	463.9	238.8	.804	-54.2	-25.9	330.1
15:00	24938	7601	432.6	222.7	.707	-26.4	-1.7	329.6
15:10	15393	4692	423.5	218.0	.667	-7.5	16.1	33.6
15:20	11461	3493	279.5	143.9	.431	3.9	14.2	25.9
15:30	11461	3493	279.2	143.7	.430	4.0	14.3	309.9
15:40	3225	983	153.3	78.9	.227	27.5	30.6	229.6
15:50	2504	763	43.8	22.6	.065	30.6	30.9	213.5

TABLE 3

FLIGHT PARAMETERS - TANK 2R COLD SOAK

JUNE 21, 1981

TIME PDT	ALTITUDE		AIRSPEED			AIR TEMP, C		HEADING DEG
	FEET	METERS	KNOTS	M/S	MACH	STATIC	TOTAL	
7:00	2537	773	15.0	7.7	0.022	28.2	28.2	100.5
7:10	2473	754	26.1	13.4	.039	28.6	28.7	100.0
7:20	7627	2325	290.0	149.3	.436	18.8	29.9	100.0
7:30	18815	5735	442.4	227.7	.698	-8.8	17.0	100.0
7:40	23079	7034	460.9	237.3	.737	-15.7	12.3	100.0
7:50	27845	8487	483.8	249.1	.792	-27.5	3.4	100.0
7:54	29737	9064	488.8	251.6	.808	-32.3	-0.8	100.0
8:10	33025	10065	491.5	253.0	.827	-40.6	-8.8	100.0
8:20	33019	10064	489.0	251.7	.824	-41.1	-9.6	100.0
8:30	33018	10064	487.1	250.7	.822	-41.9	-10.6	100.0
8:40	32980	10052	484.5	249.4	.817	-41.3	-10.4	100.0
8:50	32947	10042	487.1	250.7	.821	-41.5	-10.3	100.0
9:00	32989	10055	483.5	248.9	.817	-42.4	-11.6	100.0
9:10	33021	10064	474.1	244.1	.802	-43.2	-13.6	100.0
9:20	33039	10070	473.3	243.6	.801	-43.5	-14.0	100.0
9:30	33041	10071	474.5	244.3	.804	-43.6	-13.9	91.1
9:39	33017	10063	472.8	243.4	.801	-43.5	-14.0	84.3
9:50	33013	10062	472.5	243.2	.800	-43.4	-14.0	85.5
10:00	33007	10060	473.0	243.5	.800	-43.1	-13.6	83.7
10:10	33015	10062	473.9	244.0	.802	-42.9	-13.3	94.7
10:20	33013	10062	473.6	243.8	.801	-42.9	-13.3	95.7
10:30	33044	10071	476.0	245.0	.806	-43.7	-13.8	100.6
10:40	33029	10067	473.0	243.5	.801	-43.6	-14.1	102.8
10:50	33008	10060	473.8	243.9	.802	-43.5	-14.0	103.5
11:00	33017	10063	475.3	244.6	.802	-42.0	-12.3	119.2
11:10	32987	10054	475.1	244.6	.800	-41.1	-11.4	115.1
11:20	33194	10117	481.1	247.6	.810	-41.1	-10.6	135.5
11:30	36771	11207	483.4	248.8	.832	-50.9	-20.1	116.9
11:40	37004	11278	482.7	248.5	.831	-50.9	-20.3	53.6
11:50	36999	11277	483.6	249.0	.833	-50.9	-20.1	40.7
12:00	36993	11275	483.3	248.8	.833	-51.3	-20.5	14.2
12:10	36970	11268	479.0	246.6	.825	-51.2	-21.0	15.4
12:18	36997	11276	478.2	246.2	.825	-52.0	-21.9	21.3
12:30	36950	11262	474.9	244.4	.818	-51.5	-21.8	21.1
12:40	37007	11279	479.3	246.7	.827	-51.9	-21.6	25.2
12:50	37005	11279	477.8	245.9	.825	-52.3	-22.3	22.7
13:00	36995	11276	477.9	246.0	.826	-52.5	-22.4	23.6
13:10	27413	8355	473.2	243.6	.778	-29.4	0.1	33.0
13:20	17095	5210	396.4	204.0	.620	-4.1	16.6	34.1
13:30	6210	1893	284.3	146.4	.430	14.3	24.9	37.6
13:40	145	44	24.2	12.5	.036	28.7	28.7	177.8

TABLE 4

FLIGHT PARAMETERS - TANK 2R COLD SOAK

MARCH 9, 1981

TIME PDT	ALTITUDE		AIRSPEED			AIR TEMP, C		HEADING DEG
	FEET	METERS	KNOTS	M/S	MACH	STATIC	TOTAL	
10:20	33443	10193	576.5	296.8	.837	-50.5	-19.2	334.
10:30	34919	10643	533.2	274.5	.805	-54.1	-25.7	5.
10:40	34925	10645	534.6	275.2	.808	-55.2	-26.7	4.
10:50	34947	10652	533.8	274.8	.807	-55.5	-27.2	6.
11:00	36087	10999	509.1	262.1	.792	-57.5	-30.5	334.
11:10	36648	11170	516.3	265.8	.811	-59.3	-31.2	336.
11:20	36919	11253	508.6	261.8	.805	-60.5	-33.0	329.
11:30	36935	11258	510.7	262.9	.808	-60.7	-33.0	5.
11:40	36935	11258	516.3	265.8	.816	-61.2	-33.0	5.
11:50	36668	11176	552.8	264.6	.812	-61.1	-33.1	4.
12:00	36917	11252	513.0	264.1	.811	-61.9	-34.1	6.
12:10	36939	11259	522.3	268.9	.825	-62.2	-33.5	357.
12:20	36927	11255	504.7	259.8	.799	-61.9	-34.9	355.
12:30	36926	11255	509.9	262.5	.806	-62.3	-34.8	359.
12:40	36907	11249	513.0	264.1	.811	-62.4	-34.6	356.
12:50	36915	11252	513.8	264.5	.812	-62.4	-34.6	356.
13:00	36912	11251	516.5	265.9	.816	-63.3	-35.3	356.
13:10	36915	11252	516.3	265.8	.815	-63.5	-35.6	215.
13:16:45	37635	11471	494.4	254.5	.796	-64.1	-37.6	---
13:30	38907	11859	481.4	247.8	.798	-64.4	-37.9	190.
13:40	38881	11851	485.2	249.8	.804	-65.4	-38.6	185.
13:50	38905	11858	491.5	253.0	.813	-66.4	-39.1	188.
14:00	38893	11855	473.6	243.8	.786	-55.1	-28.1	180.
14:10	36906	11249	520.6	268.0	.821	-61.8	-33.3	175.
14:20	36934	11257	517.1	266.2	.817	-62.0	-33.8	179.
14:30	36867	11237	516.9	266.1	.815	-61.2	-33.0	175.
14:40	36909	11250	515.2	265.2	.814	-59.9	-31.7	175.
14:50	36905	11249	516.3	265.8	.815	-58.8	-30.3	187.
15:00	36885	11243	515.0	265.1	.813	-59.2	-30.9	184.
15:10	37858	11539	501.4	258.1	.810	-57.0	-28.7	162.
15:20	38900	11857	489.5	252.0	.810	-57.0	-28.6	162.
15:30	38921	11863	496.1	255.4	.820	-60.1	-31.4	160.
15:40	38895	11855	506.2	260.6	.835	-61.0	-31.4	164.
15:50	38878	11850	484.3	249.3	.802	-60.4	-33.1	164.
16:00	38916	11862	507.4	261.2	.837	-60.8	-31.0	185.
16:10	38939	11867	515.9	265.6	.850	-60.7	-30.0	185.
16:20	38891	11854	479.6	246.9	.795	-59.4	-32.4	117.
16:30	38902	11857	491.8	253.2	.814	-58.3	-29.8	121.
16:40	38871	11848	466.8	240.3	.776	-56.1	-29.9	176.
16:50	35912	10946	537.1	276.5	.827	-56.0	-26.2	168.
17:00	10012	3052	591.9	304.7	.549	2.7	19.4	169.
17:10	9968	3038	452.6	233.0	.422	3.5	13.3	70.
17:20	4653	1418	351.0	180.7	.297	16.2	21.3	--
17:30	3563	1086	289.0	148.8	.240	19.8	23.1	--
17:40	6969	2124	465.8	239.8	.411	9.2	18.7	--
17:50	2510	765	23.7	12.2	.019	--	--	--

TABLE 5A

FUEL QUANTITIES - TANK 1 COLD SOAK

APRIL 23, 1981

TIME PDT	FUEL IN TANKS - KGS				FUEL TEMP,C	COMMENTS
	2L	1	3	2R		
8:49						IN STALL
8:52	11022	25084	24948	10569	25.0	BLOCK OUT
9:02	11045	24902	24880	10179	25.0	GROUND RUN
9:12:35						TAKE OFF
9:20	9843	25084	24222	10160	25.0	CLIMB
9:30	9616	25084	23768	10637	25.0	CLIMB
9:40	8981	25084	21999	10183	25.0	
9:50	9004	25084	20902	9775	25.0	CLIMB
10:00	8709	25084	19595	9457	23.0	CLIMB
10:10	8528	25084	18416	8165	20.0	
10:12:20	8528	25084	18189	8097	20.0	START TEST
10:20	8473	25084	17318	7915	17.5	
10:30	8391	25084	16171	7824	13.0	
10:40	8255	25084	15173	7711	10.0	LIGHT TURBULENCE
10:50	8119	25084	14334	8482	9.0	
11:00	7756	25084	14243	7893	7.0	
11:10	6863	25084	14188	7212	3.0	SMOOTH AIR
11:20	6192	25084	14152	6350	0.0	
11:30	5511	25084	14265	5670	-4.0	
11:40	5262	25084	13630	5420	-6.0	
11:50	5080	25084	12406	5094	-6.0	LIGHT TURBULENCE
12:00	4853	25084	11431	4853	-6.0	
12:10	4717	25084	10659	4400	-7.0	
12:20	4763	25084	9208	4445	-10.0	
12:30	4445	25084	8618	4445	-10.0	SMOOTH AIR
12:40	4286	25084	7802	4164	-10.5	
12:50	3674	25084	7711	3425	-12.0	
13:00	3370	25084	6876	3334	-12.5	
13:10	3039	25084	6554	2926	-13.0	
13:20	2835	25084	8958	2880	-13.0	
13:30	2676	25084	4672	2676	-12.0	
13:40	2381	25084	4840	2077	-13.0	
13:50	1973	25084	4286	1973	-15.0	
14:00	1792	25084	3629	1746	-15.0	
14:10	1520	25084	3107	1406	-15.0	
14:20	1202	25084	2427	1134	-14.0	
14:30	1202	25084	930	1093	-14.0	
14:40	658	25084	862	567	-15.0	

TABLE 5A (CONCLUDED)

FUEL QUANTITIES - TANK 1 COLD SOAK APRIL 23, 1981

TIME PDT	FUEL IN TANKS - KGS				FUEL TEMP,C	COMMENTS
	2L	1	3	2R		
14:42						START DESCENT
14:56	1043	21591	2064	3379	-10.0	
15:00	885	20548	2132	4536	-9.0	
15:02	839	20366	1905	4536	-9.0	
15:05	590	21137	2268	4400	-8.0	
15:08	839	20026	1769	4513	-6.5	
15:12	499	21727	1043	4400	-5.0	
15:16	1157	19391	1701	3878	-5.0	
15:19	1157	19391	1701	3878	-5.0	
15:39	1247	19641	1066	1950	6.5	
15:40	1542	18665	658	1905	6.5	
15:43	1633	18461	340	1973	7.0	
15:46	1420	18724	249	1497	7.0	
16:10	953	11340	2790	3538	7.0	
16:24:28						LANDING
16:30	1012	8981	4377	2858	15.0	END DATA

TABLE 5B

FUEL QUANTITIES - TANK 1 COLD SOAK APRIL 23, 1981

TIME PDT	FUEL IN TANKS - LBS				FUEL TEMP,C	COMMENTS
----	2L	1	3	2R	-----	-----
8:49						IN STALL
8:52	24300	55300	55000	23300	25.0	BLOCK OUT
9:02	24350	54900	54850	22440	25.0	GROUND RUN
9:12:35						TAKE OFF
9:20	21700	55300	53400	22400	25.0	CLIMB
9:30	21200	55300	52400	23450	25.0	CLIMB
9:40	19800	55300	48500	22450	25.0	
9:50	19850	55300	46080	21550	25.0	CLIMB
10:00	19200	55300	43200	20850	23.0	CLIMB
10:10	18800	55300	40600	18000	20.0	
10:12:20	18800	55300	40100	17850	20.0	START TEST
10:20	18680	55300	38180	17450	17.5	
10:30	18500	55300	35650	17250	13.0	
10:40	18200	55300	33450	17000	10.0	LIGHT TURBULENCE
10:50	17900	55300	31600	18700	9.0	
11:00	17100	55300	31400	17400	7.0	
11:10	15130	55300	31280	15900	3.0	SMOOTH AIR
11:20	13650	55300	31200	14000	0.0	
11:30	12150	55300	31450	12500	-4.0	
11:40	11600	55300	30050	11950	-6.0	
11:50	11200	55300	27350	11230	-6.0	LIGHT TURBULENCE
12:00	10700	55300	25200	10700	-6.0	
12:10	10400	55300	23500	9700	-7.0	
12:20	10500	55300	20300	9800	-10.0	
12:30	9800	55300	19000	9800	-10.0	SMOOTH AIR
12:40	9450	55300	17200	9180	-10.5	
12:50	8100	55300	17000	7550	-12.0	
13:00	7430	55300	15160	7350	-12.5	
13:10	6700	55300	14450	6450	-13.0	
13:20	6250	55300	19750	6350	-13.0	
13:30	5900	55300	10300	5900	-12.0	
13:40	5250	55300	10670	4580	-13.0	
13:50	4350	55300	9450	4350	-15.0	
14:00	3950	55300	8000	3850	-15.0	
14:10	3350	55300	6850	3100	-15.0	
14:20	2650	55300	5350	2500	-14.0	
14:30	2650	55300	2050	2410	-14.0	
14:40	1450	55300	1900	1250	-15.0	

TABLE 5B (CONCLUDED)

FUEL QUANTITIES - TANK 1 COLD SOAK APRIL 23, 1981

TIME PDT	FUEL IN TANKS - LBS				FUEL TEMP,C	COMMENTS
	2L	1	3	2R		
14:42						START DESCENT
14:56	2300	47600	4550	7450	-10.0	
15:00	1950	45300	4700	10000	-9.0	
15:02	1850	44900	4200	10000	-9.0	
15:05	1300	46600	5000	9700	-8.0	
15:08	1850	44150	3900	9950	-6.5	
15:12	1100	47900	2300	9700	-5.0	
15:16	2550	42750	3750	8550	-5.0	
15:19	2550	42750	3750	8550	-5.0	
15:39	2750	43300	2350	4300	6.5	
15:40	3400	41150	1450	4200	6.5	
15:43	3600	40700	750	4350	7.0	
15:46	3130	41280	550	3300	7.0	
16:10	2100	25000	6150	7800	7.0	
16:24:28						LANDING
16:30	2230	19800	9650	6300	15.0	END DATA

TABLE 6A

FUEL QUANTITIES - TANK 2R COLD SOAK APRIL 30, 1981

TIME PDT	FUEL IN TANKS - KGS				FUEL TEMP,C	COMMENTS
	2L	1	3	2R		
8:20	11476	25061	24916	10614	27.0	
8:30	11431	24902	24902	10591	27.0	
8:39						
8:40	11431	24403	24358	10591	27.0	START TAXI
8:55	11376	23691	24585	10591	27.0	FIRST DATA POINT
8:58						
9:00	11748	23700	24675	10954	27.0	TAKE OFF
9:10	11567	23292	24335	10795	27.0	
9:20	11431	21659	24108	10637	27.0	
9:30	11272	20071	23111	10433	26.0	
9:40	11226	18869	22330	10387	24.0	
9:50	11204	18053	21546	10251	12.5	START CRUISE FL 350
10:00	11249	17418	21115	10319	7.5	
10:10	11272	16647	20616	11204	4.0	
10:20	11340	16012	20230	11249	2.0	
10:30	11249	15989	18869	11181	0.0	
10:40	11294	16148	17599	11181	0.0	
10:50	11294	16239	16261	11181	-1.0	
11:00	11294	15808	15377	11181	-2.0	
11:10	11272	14878	15105	11158	-3.0	
11:20	11294	13971	14878	11136	-4.5	
11:30	11294	13608	13971	11158	-5.5	
11:40	11340	13381	12927	11113	-7.0	
11:50	11340	12360	12746	11113	-8.0	
12:00	11340	12066	11998	11113	-9.0	
12:10	11340	11567	11068	11068	-9.0	
12:20	11340	10591	10659	11113	-9.5	
12:30	11362	9766	10387	11090	-9.5	
12:40	11340	9480	9525	11022	-9.5	
12:45						START CLIMB
12:50	11340	9208	8868	11068	-9.5	
12:53						LEVEL FL 370
13:00	11408	8346	8550	11068	-10.0	
13:10	11340	7847	7893	11045	-12.0	
13:20	11385	7371	7257	11022	-13.0	
13:30	11431	6872	6736	11068	-14.5	
13:40	11431	6182	6509	11045	-16.0	
13:50	11431	5851	5738	11022	-16.5	
14:00	11385	4944	5488	11068	-16.5	
14:10	11476	4604	4695	11045	-16.0	
14:20	11499	4332	3856	11136	-15.0	
14:30	11431	3425	3697	11045	-14.5	
14:40	11408	3053	2939	11045	-14.5	
14:50	11431	2200	2608	11113	-15.0	
14:52						END CRUISE
15:00	10977	1996	2540	10841	-14.5	
15:10	10342	2109	2676	10206	-11.5	
15:20	9730	2245	2767	9616	-8.0	
15:30	9208	2336	2948	9026	-5.5	
15:42	8664	2472	3221	8709	2.5	LANDING
16:00	7756	2767	3561	7870	5.0	END DATA

TABLE 6B

FUEL QUANTITIES - TANK 2R COLD SOAK APRIL 30, 1981

TIME PDT	FUEL IN TANKS - LBS				FUEL TEMP,C	COMMENTS
	2L	1	3	2R		
8:20	25300	55250	54930	23400	27.0	
8:30	25200	54900	54900	23350	27.0	
8:39						START TAXI
8:40	25200	53800	53700	23350	27.0	FIRST DATA POINT
8:55	25080	52230	54200	23350	27.0	
8:58						TAKE OFF
9:00	25900	52250	54400	24150	27.0	
9:10	25500	51350	53650	23800	27.0	
9:20	25200	47750	53150	23450	27.0	
9:30	24850	44250	50950	23000	26.0	
9:40	24750	41600	49230	22900	24.0	
9:50	24700	39800	47500	22600	12.5	START CRUISE FL 350
10:00	24800	38400	46550	22750	7.5	
10:10	24850	36700	45450	24700	4.0	
10:20	25000	35300	44600	24800	2.0	
10:30	24800	35250	41600	24650	0.0	
10:40	24900	35600	38800	24650	0.0	
10:50	24900	35800	35850	24650	-1.0	
11:00	24900	34850	33900	24650	-2.0	
11:10	24850	32800	33300	24600	-3.0	
11:20	24900	30800	32800	24550	-4.5	
11:30	24900	30000	30800	24600	-5.5	
11:40	25000	29500	28500	24500	-7.0	
11:50	25000	27250	28100	24500	-8.0	
12:00	25000	26600	26450	24500	-9.0	
12:10	25000	25500	24400	24400	-9.0	
12:20	25000	23350	23500	24500	-9.5	
12:30	25050	21530	22900	24450	-9.5	
12:40	25000	20900	21000	24300	-9.5	
12:45						START CLIMB
12:50	25000	20300	19550	24400	-9.5	
12:53						LEVEL FL 370
13:00	25150	18400	18850	24400	-10.0	
13:10	25000	17300	17400	24350	-12.0	
13:20	25100	16250	16000	24300	-13.0	
13:30	25200	15150	14850	24400	-14.5	
13:40	25200	13630	14350	24350	-16.0	
13:50	25200	12900	12650	24300	-16.5	
14:00	25100	10900	12100	24400	-16.5	
14:10	25300	10150	10350	24350	-16.0	
14:20	25350	9550	8500	24550	-15.0	
14:30	25200	7550	8150	24350	-14.5	
14:40	25150	6730	6480	24350	-14.5	
14:50	25200	4850	5750	24500	-15.0	
14:52						END CRUISE
15:00	24200	4400	5600	23900	-14.5	
15:10	22800	4650	5900	22500	-11.5	
15:20	21450	4950	6100	21200	-8.0	
15:30	20300	5150	6500	19900	-5.5	
15:42	19100	5450	7100	19200	2.5	LANDING
16:00	17100	6100	7850	17350	5.0	END DATA

TABLE 7A

FUEL QUANTITIES - TANK 2R COLD SOAK JUNE 21, 1981

TIME PDT	2L	1	3	2R	FUEL TEMP,C	COMMENTS
7:00						
7:04						FIRST DATA POINT
7:16						START TAXI
7:30	10478	20094	23042	11385	30.0	TAKE OFF
7:40	10478	19459	21591	11294	28.0	
7:50	10478	19051	20593	11249	23.0	
8:00	10478	18552	19595	11158	18.0	
8:06						START CRUISE FL 330
8:10	10433	18053	18688	11113	12.0	
8:20	10478	17599	17872	11068	8.0	
8:30	10478	17100	16919	11113	5.0	
8:40	10478	16103	16692	11068	2.0	
8:50	10523	15331	16239	11068	0.0	
9:00	10569	14969	15513	11022	0.0	
9:10	10569	14515	14606	11022	-2.0	
9:20	10569	14061	13744	10977	-3.0	
9:30	10614	13426	13109	10932	-5.0	
9:40	10614	12383	12791	10932	-7.0	
9:50	10659	11884	12066	10932	-7.0	
10:00	10659	11340	11113	10886	-7.0	
10:10	10659	10705	12610	10886	-8.0	
10:20	10659	9843	10115	10886	-9.0	
10:30	10659	9480	9435	10886	-10.0	
10:40	10705	9072	8664	10932	-10.0	
10:50	10705	8119	8437	10932	-11.0	
11:00	10705	7575	7711	10932	-12.0	
11:10	10705	6804	7076	10932	-12.0	
11:20	10705	6486	6441	10932	-12.0	START CLIMB
11:25	10705	5307	5806	10932	-12.0	
11:30						LEVEL FL 370
11:40	10705	4536	5625	10977	-13.0	
11:50	10750	4354	4990	10886	-14.0	
12:00	10705	3992	4218	10932	-14.0	
12:12	10750	3493	3447	10932	-14.0	
12:20	10750	2631	3221	10932	-16.0	
12:30	10750	2268	2404	10977	-16.0	
12:40	10750	1542	1678	10932	-16.0	
12:50	10750	862	862	10932	-16.0	
13:00	9571	726	726	10932	-16.0	
13:06	8981	771	862	10932	-16.0	
13:07						END CRUISE
13:39						LANDING
13:40						END DATA

TABLE 7B

FUEL QUANTITIES - TANK 2R COLD SOAK JUNE 21, 1981

TIME PDT	FUEL IN TANKS - LBS				FUEL TEMP,C	COMMENTS
----	2L	1	3	2R	-----	-----
7:00						FIRST DATA POINT
7:04						START TAXI
7:16						TAKE OFF
7:30	23100	44300	50800	25100	30.0	
7:40	23100	42900	47600	24900	28.0	
7:50	23100	42000	45400	24800	23.0	
8:00	23100	40900	43200	24600	18.0	
8:06						START CRUISE FL 330
8:10	23000	39800	41200	24500	12.0	
8:20	23100	38800	39400	24400	8.0	
8:30	23100	37700	37300	24500	5.0	
8:40	23100	35500	36800	24400	2.0	
8:50	23200	33800	35800	24400	0.0	
9:00	23300	33000	34200	24300	0.0	
9:10	23300	32000	32200	24300	-2.0	
9:20	23300	31000	30300	24200	-3.0	
9:30	23400	29600	28900	24100	-5.0	
9:40	23400	27300	28200	24100	-7.0	
9:50	23500	26200	26600	24100	-7.0	
10:00	23500	25000	24500	24000	-7.0	
10:10	23500	23600	27800	24000	-8.0	
10:20	23500	21700	22300	24000	-9.0	
10:30	23500	20900	20800	24000	-10.0	
10:40	23600	20000	19100	24100	-10.0	
10:50	23600	17900	18600	24100	-11.0	
11:00	23600	16700	17000	24100	-12.0	
11:10	23600	15000	15600	24100	-12.0	
11:20	23600	14300	14200	24100	-12.0	START CLIMB
11:25	23600	11700	12800	24100	-12.0	
11:30						LEVEL FL 370
11:40	23600	10000	12400	24200	-13.0	
11:50	23700	9600	11000	24000	-14.0	
12:00	23600	8800	9300	24100	-14.0	
12:12	23700	7700	7600	24100	-14.0	
12:20	23700	5800	7100	24100	-16.0	
12:30	23700	5000	5300	24200	-16.0	
12:40	23700	3400	3700	24100	-16.0	
12:50	23700	1900	1900	24100	-16.0	
13:00	21100	1600	1600	24100	-16.0	
13:06	19800	1700	1900	24100	-16.0	
13:07						END CRUISE
13:39						LANDING
13:40						END DATA

TABLE 8A

FUEL QUANTITIES - TANK 2R COLD SOAK

MARCH 9, 1983

TIME PDT	2L	1	3	2R	FUEL TEMP,C	COMMENTS
9:30	11635	24993	25084	11476	17	
9:40	11612	24313	24993	11521	17	ON GROUND
9:45						TAKEOFF
9:50	11975	24086	24812	11793	16	SMOOTH AIR CLIMB
10:00	11340	22453	24494	11476	17	SOME TURBULENCE
10:10	11204	21001	23632	11340	14	SMOOTH AIR CLIMB
10:20	10977	20502	22226	11249	5	SMOOTH AIR CLIMB
10:24:38						SMOOTH AIR LEVEL FL 350
10:30	11294	20321	21364	11204	-2	SMOOTH AIR
10:40	11294	19867	20502	11204	-7	VERY LIGHT TURB 10% OF TIME
10:50	11294	19414	19686	11249	-10	VERY LIGHT TURB 15% OF TIME
11:00	11340	19096	18960	11204	-15	SMOOTH AIR CLIMB
11:10	11340	18552	18325	11249	-15	LIGHT TURB 10% OF TIME
11:12						CLIMB
11:20						LEVEL FL 370
11:20	11385	18098	17463	11158	-17	VERY LIGHT TURB 10% OF TIME
11:30	11431	17282	17055	11204	-18	SMOOTH AIR
11:40	11385	16375	16738	11113	-20	SMOOTH AIR
11:50	11385	15785	16193	11158	-22	SMOOTH AIR
12:00	11385	15331	15331	11158	-24	SMOOTH AIR
12:10	11385	14969	14470	11158	-25	VERY LIGHT TURB 15% OF TIME
12:20	11476	13971	14016	11385	-25	VERY LIGHT TURB 20% OF TIME
12:30	11476	13608	13154	11385	-26	VERY LIGHT TURB 10% OF TIME
12:40	11476	12791	12701	11385	-27	SMOOTH AIR
12:50	11476	11929	12292	11431	-28	SMOOTH AIR
13:00	11521	11612	11476	11385	-28	VERY LIGHT TURB 20% OF TIME
13:10	11476	11068	10523	11385	-29	VERY LIGHT TURB 10% OF TIME
13:20						TURN
13:20	11521	10206	10342	11431	-30	CLIMB
13:28						LEVEL FL 390
13:30	11567	9888	9525	11431	-31	SMOOTH AIR
13:40	11567	9525	8890	11431	-32	SMOOTH AIR
13:50	11567	9163	8074	11431	-33	SMOOTH AIR
14:00	11567	8074	7893	11476	-33	LIGHT TURB 20% OF TIME
14:03						OUT OF TURBULENCE
14:10	11521	7394	7530	11431	-33	SMOOTH AIR
14:20	11612	6849	6713	11612	-33	SMOOTH AIR
14:30	11567	6169	6396	11657	-33	SMOOTH AIR
14:40	11567	5806	5670	11657	-33	SMOOTH AIR
14:50	11612	5352	4990	11657	-33	SMOOTH AIR
15:00	11612	4581	4627	11657	-32	SMOOTH AIR
15:10	11612	3946	4037	11703	-32	LIGHT TURB 30% OF TIME
15:20	11612	3674	3402	11703	-32	LIGHT TURB 40% OF TIME
15:30	11612	2812	3039	11657	-31	LIGHT TURB 10% OF TIME
15:40	11612	2087	2540	11657	-30	SMOOTH AIR
15:50	11612	1406	1542	11703	-30	LIGHT TURB 10% OF TIME

TABLE 8A (CONCLUDED)

FUEL QUANTITIES - TANK 2R COLD SOAK MARCH 9, 1983

TIME PDT	FUEL IN TANKS - KGS				FUEL TEMP,C	COMMENTS
	2L	1	3	2R		
16:00	10614	1361	1361	11657	-30	SMOOTH AIR
16:10	9253	1588	1678	11657	-30	SMOOTH AIR
16:20	8255	1542	1406	11657	-30	SMOOTH AIR
16:30	7076	1769	2132	11657	-30	SMOOTH AIR
16:40	6940	1134	1361	11657	-30	SMOOTH AIR
16:41						START PUMPOUT OF TANK 2R
16:48						START DESCENT
16:50	7212	1451	1497	10433	-30	DESCENT
17:00	7212	1633	1724	9662	-28	LEVEL FL 100
17:10	6577	1678	1769	8754	-24	
17:20	6532	1588	----	6985	-18	
17:25						TOUCHDOWN
17:30	5080	2087	2359	5307	-10	
17:31						ON GROUND
17:40	5307	2041	2404	5080	-3	
17:50	5080	2132	----	4808		END DATA

TABLE 8B

FUEL QUANTITIES - TANK 2R COLD SOAK MARCH 9, 1983

TIME PDT	FUEL IN TANKS - LBS				FUEL TEMP,C	COMMENTS
---	2L	1	3	2R	----	-----
9:30	25650	55100	55300	25300	17	
9:40	25600	53600	55100	25400	17	ON GROUND
9:45						TAKEOFF
9:50	26400	53100	54700	26000	16	SMOOTH AIR CLIMB
10:00	25000	49500	54000	25300	17	SOME TURBULENCE
10:10	24700	46300	52100	25000	14	SMOOTH AIR CLIMB
10:20	24200	45200	49000	24800	5	SMOOTH AIR CLIMB
10:24:38						SMOOTH AIR LEVEL FL 350
10:30	24900	44800	47100	24700	-2	SMOOTH AIR
10:40	24900	43800	45200	24700	-7	VERY LIGHT TURB 10% OF TIME
10:50	24900	42800	43400	24800	-10	VERY LIGHT TURB 15% OF TIME
11:00	25000	42100	41800	24700	-15	SMOOTH AIR CLIMB
11:10	25000	40900	40400	24800	-15	LIGHT TURB 10% OF TIME
11:12						CLIMB
						LEVEL FL 370
11:20	25100	39900	38500	24600	-17	VERY LIGHT TURB 10% OF TIME
11:30	25200	38100	37600	24700	-18	SMOOTH AIR
11:40	25100	36100	36900	24500	-20	SMOOTH AIR
11:50	25100	34800	35700	24600	-22	SMOOTH AIR
12:00	25100	33800	33800	24600	-24	SMOOTH AIR
12:10	25100	33000	31900	24600	-25	VERY LIGHT TURB 15% OF TIME
12:20	25300	30800	30900	25100	-25	VERY LIGHT TURB 20% OF TIME
12:30	25300	30000	29000	25100	-26	VERY LIGHT TURB 10% OF TIME
12:40	25300	28200	28000	25100	-27	SMOOTH AIR
12:50	25300	26300	27100	25200	-28	SMOOTH AIR
13:00	25400	25600	25300	25100	-28	VERY LIGHT TURB 20% OF TIME
13:10	25300	24400	23200	25100	-29	VERY LIGHT TURB 10% OF TIME
						TURN
13:20	25400	22500	22800	25200	-30	CLIMB
13:28						LEVEL FL 390
13:30	25500	21800	21000	25200	-31	SMOOTH AIR
13:40	25500	21000	19600	25200	-32	SMOOTH AIR
13:50	25500	20200	17800	25200	-33	SMOOTH AIR
14:00	25500	17800	17400	25300	-33	LIGHT TURB 20% OF TIME
14:03						OUT OF TURBULENCE
14:10	25400	16300	16600	25200	-33	SMOOTH AIR
14:20	25600	15100	14800	25600	-33	SMOOTH AIR
14:30	25500	13600	14100	25700	-33	SMOOTH AIR
14:40	25500	12800	12500	25700	-33	SMOOTH AIR
14:50	25600	11800	11000	25700	-33	SMOOTH AIR
15:00	25600	10100	10200	25700	-32	SMOOTH AIR
15:10	25600	8700	8900	25800	-32	LIGHT TURB 30% OF TIME
15:20	25600	8100	7500	25800	-32	LIGHT TURB 40% OF TIME
15:30	25600	6200	6700	25700	-31	LIGHT TURB 10% OF TIME
15:40	25600	4600	5600	25700	-30	SMOOTH AIR
15:50	25600	3100	3400	25800	-30	LIGHT TURB 10% OF TIME

TABLE 8B (CONCLUDED)

FUEL QUANTITIES - TANK 2R COLD SOAK MARCH 9, 1983

TIME PDT	FUEL IN TANKS - LBS				FUEL TEMP,C	COMMENTS
	2L	1	3	2R		
16:00	23400	3000	3000	25700	-30	SMOOTH AIR
16:10	20400	3500	3700	25700	-30	SMOOTH AIR
16:20	18200	3400	3100	25700	-30	SMOOTH AIR
16:30	15600	3900	4700	25700	-30	SMOOTH AIR
16:40	15300	2500	3000	25700	-30	SMOOTH AIR
16:41						START PUMPOUT OF TANK 2R
16:48						START DESCENT
16:50	15900	3200	3300	23000	-30	DESCENT
17:00	15900	3600	3800	21300	-28	LEVEL FL 100
17:10	14500	3700	3900	19300	-24	
17:20	14400	3500	----	15400	-18	
17:25						TOUCHDOWN
17:30	11200	4600	5200	11700	-10	
17:31						ON GROUND
17:40	11700	4500	5300	11200	-3	
17:50	11200	4700	----	10600	0	END DATA

TABLE 9A

TANK 1 TEMPERATURE DISTRIBUTION, C

APRIL 23, 1981

T/C HEIGHT		PACIFIC DAYLIGHT TIME					
IN	CM	9:00	9:10	9:20	9:30	9:40	9:50
-----	-----	-----	-----	-----	-----	-----	-----
46.00	116.8	21.8	21.3	20.5	19.2	18.0	14.8
45.50	115.6	21.6	21.3	21.3	21.0	20.8	20.5
45.00	114.3	21.3	21.2	21.2	20.9	20.8	20.4
44.00	111.8	21.3	21.3	21.3	21.1	20.9	20.6
42.00	106.7	21.0	21.2	21.2	21.1	20.9	20.6
38.00	96.5	20.9	21.0	21.1	21.1	21.0	20.6
34.00	86.4	20.7	20.8	21.0	20.9	20.8	20.5
30.00	76.2	20.6	20.8	20.9	20.8	20.7	20.5
26.00	66.0	20.6	20.8	20.9	20.9	20.7	20.5
22.00	55.9	20.6	20.7	20.8	20.7	20.6	20.3
18.00	45.7	20.5	20.7	20.8	20.7	20.6	20.3
14.00	35.6	20.4	20.6	20.8	20.6	20.4	20.1
10.00	25.4	20.3	20.5	20.7	20.5	20.1	19.8
8.00	20.3	20.4	20.5	20.7	20.6	20.1	19.7
6.00	15.2	20.3	20.5	20.7	20.5	19.8	19.3
4.00	10.2	20.3	20.5	20.7	20.4	19.7	19.0
2.00	5.1	20.3	20.5	20.7	20.5	19.8	18.8
1.00	2.5	20.3	20.5	20.6	20.3	19.5	18.5
0.50	1.3	20.3	20.5	20.6	20.1	19.3	18.2
0.25	0.6	20.1	20.3	20.3	19.2	18.4	16.1
0.00	0.0	20.8	21.0	19.7	18.5	17.2	13.7
		10:00	10:10	10:20	10:30	10:40	10:50
		-----	-----	-----	-----	-----	-----
46.00	116.8	9.8	6.8	6.0	4.4	3.3	2.6
45.50	115.6	19.6	18.4	17.2	15.9	14.3	12.6
45.00	114.3	19.5	18.5	17.2	15.9	14.4	12.7
44.00	111.8	19.6	18.5	17.2	15.9	14.4	12.7
42.00	106.7	19.9	18.7	17.6	16.2	14.5	12.7
38.00	96.5	19.9	18.8	17.7	16.3	14.6	12.9
34.00	86.4	19.8	18.7	17.4	16.1	14.5	12.8
30.00	76.2	19.7	18.7	17.2	15.9	14.3	12.7
26.00	66.0	19.7	18.4	17.1	15.5	13.9	12.1
22.00	55.9	19.5	18.2	16.8	15.1	13.4	11.6
18.00	45.7	19.4	18.0	16.3	14.6	12.8	11.2
14.00	35.6	19.1	17.8	16.0	13.7	11.4	9.5
10.00	25.4	18.6	16.4	13.4	10.3	8.0	6.5
8.00	20.3	18.2	15.1	11.5	8.2	5.9	4.3
6.00	15.2	17.0	13.3	9.0	6.1	2.9	1.7
4.00	10.2	15.5	11.1	6.6	3.2	0.1	0.5
2.00	5.1	13.3	7.4	2.7	-0.5	-1.6	0.4
1.00	2.5	11.5	6.0	1.2	-2.1	-2.1	0.3
0.50	1.3	10.2	4.9	0.3	-3.0	-2.6	0.1
0.25	0.6	6.6	-1.0	-3.5	-8.3	-6.2	-2.7
0.00	0.0	4.0	-3.6	-7.8	-10.7	-12.2	-9.5

TABLE 9A (CONTINUED)

TANK 1 TEMPERATURE DISTRIBUTION, C

APRIL 23, 1981

T/C HEIGHT		PACIFIC DAYLIGHT TIME					
IN	CM	11:00	11:10	11:20	11:30	11:40	11:50
-----	-----	-----	-----	-----	-----	-----	-----
46.00	116.8	1.2	0.6	-0.1	-0.6	-1.7	-2.4
45.50	115.6	10.8	9.5	8.4	7.7	6.5	5.7
45.00	114.3	10.8	9.5	8.4	7.6	6.5	5.6
44.00	111.8	10.9	9.5	8.5	7.8	6.7	5.7
42.00	106.7	10.9	9.9	8.7	7.9	6.9	5.8
38.00	96.5	11.0	9.8	8.8	7.9	6.9	5.9
34.00	86.4	10.9	9.8	8.7	7.6	6.7	5.7
30.00	76.3	10.8	9.4	8.4	7.3	6.3	5.0
26.00	66.0	10.5	8.8	7.8	6.5	5.5	4.3
22.00	55.9	10.0	8.4	7.2	5.6	4.3	3.1
18.00	45.7	9.2	7.9	6.0	4.5	2.9	1.9
14.00	35.6	8.2	6.2	4.3	2.7	1.2	0.0
10.00	25.4	5.7	3.3	1.3	-0.2	-1.8	-2.6
8.00	20.3	3.3	1.7	-0.2	-1.9	-3.4	-4.5
6.00	15.2	1.5	0.4	-1.5	-3.5	-5.0	-6.0
4.00	10.2	0.8	-0.6	-2.7	-4.6	-6.3	-6.9
2.00	5.1	0.9	-1.4	-4.3	-5.7	-7.5	-7.4
1.00	2.5	0.9	-2.0	-5.0	-6.3	-8.2	-7.7
0.50	1.3	0.8	-2.5	-5.8	-6.7	-8.7	-8.1
0.25	0.6	-1.9	-7.9	-9.4	-10.7	-12.3	-11.7
0.00	0.0	-8.3	-10.6	-11.8	-12.6	-13.7	-13.3
		12:00	12:10	12:20	12:30	12:40	12:50
		-----	-----	-----	-----	-----	-----
46.00	116.8	-4.2	-5.4	-6.4	-8.1	-8.7	-8.9
45.50	115.6	4.3	2.4	1.0	-0.4	-0.8	-1.5
45.00	114.3	4.3	2.4	1.0	-0.3	-0.9	-1.5
44.00	111.8	4.4	2.5	1.1	-0.2	-0.8	-1.4
42.00	106.7	4.5	2.7	1.3	0.1	-0.6	-1.3
38.00	96.5	4.6	2.8	1.4	0.1	-0.6	-1.3
34.00	86.4	4.5	2.7	1.2	0.0	-0.7	-1.4
30.00	76.2	4.5	2.6	1.2	0.0	-0.9	-1.6
26.00	66.0	3.3	2.7	1.2	0.0	-1.3	-2.3
22.00	55.9	2.1	1.3	0.6	-0.8	-2.1	-3.0
18.00	45.7	0.9	0.1	-0.6	-1.6	-2.8	-3.9
14.00	35.6	-1.1	-1.5	-2.2	-2.8	-4.0	-5.5
10.00	25.4	-4.1	-3.3	-3.9	-4.6	-6.3	-7.8
8.00	20.3	-5.6	-4.8	-5.0	-5.7	-7.5	-8.8
6.00	15.2	-7.1	-6.1	-5.9	-6.8	-8.3	-10.3
4.00	10.2	-8.0	-6.6	-6.6	-7.5	-9.3	-11.7
2.00	5.1	-8.2	-6.8	-6.9	-7.7	-10.6	-13.0
1.00	2.5	-8.4	-7.0	-7.1	-7.9	-11.6	-13.7
0.50	1.3	-8.7	-7.1	-7.3	-8.0	-12.4	-14.4
0.25	0.6	-12.1	-9.2	-10.2	-11.0	-15.3	-16.1
0.00	0.0	-15.3	-12.9	-13.1	-14.3	-16.6	-17.5

TABLE 9A (CONTINUED)

TANK 1 TEMPERATURE DISTRIBUTION, C

APRIL 23, 1981

T/C HEIGHT		PACIFIC DAYLIGHT TIME					
IN	CM	13:00	13:10	13:20	13:30	13:40	13:50
46.00	116.8	-9.7	-10.9	-10.8	-11.9	-13.0	-12.8
45.50	115.6	-2.2	-3.0	-3.7	-4.5	-5.3	-5.7
45.00	114.3	-2.4	-3.0	-3.7	-4.5	-5.3	-5.8
44.00	111.8	-2.2	-2.8	-3.7	-4.4	-5.2	-5.6
42.00	106.7	-2.0	-2.8	-3.5	-4.1	-4.9	-5.6
38.00	96.5	-2.0	-2.7	-3.4	-4.2	-4.9	-5.6
34.00	86.4	-2.1	-2.9	-3.6	-4.3	-5.1	-6.0
30.00	76.2	-2.3	-3.3	-4.1	-4.9	-5.8	-6.6
26.00	66.0	-3.0	-3.8	-4.9	-5.8	-6.6	-7.5
22.00	55.9	-4.0	-5.1	-6.2	-7.1	-7.9	-8.6
18.00	45.7	-5.1	-6.1	-7.3	-8.0	-8.9	-9.9
14.00	35.6	-6.9	-8.0	-8.9	-10.0	-10.6	-11.4
10.00	25.4	-9.0	-10.4	-11.4	-12.3	-13.2	-14.0
8.00	20.3	-10.2	-11.5	-12.8	-13.7	-14.3	-15.2
6.00	15.2	-11.6	-12.9	-14.3	-14.9	-15.6	-16.7
4.00	10.2	-13.1	-14.5	-15.4	-16.5	-17.0	-18.1
2.00	5.1	-14.6	-16.1	-16.9	-17.6	-18.1	-19.0
1.00	2.5	-15.2	-16.9	-17.5	-18.0	-18.8	-19.5
0.50	1.3	-15.8	-17.6	-18.1	-18.2	-19.4	-20.0
0.25	0.6	-18.6	-19.9	-20.1	-20.0	-21.1	-21.4
0.00	0.0	-19.2	-20.3	-20.4	-20.6	-21.2	-21.5
		14:00	14:10	14:20	14:30	14:40	14:50
46.00	116.8	-13.1	-13.5	-14.3	-15.1	-15.6	-8.4
45.50	115.6	-6.5	-7.2	-7.9	-8.4	-9.1	-9.1
45.00	114.3	-6.5	-7.2	-7.9	-8.5	-9.2	-9.2
44.00	111.8	-6.4	-7.1	-7.7	-8.4	-9.1	-9.1
42.00	106.7	-6.3	-7.0	-7.6	-8.3	-8.9	-9.3
38.00	96.5	-6.3	-7.0	-7.6	-8.3	-9.0	-9.7
34.00	86.4	-6.6	-7.3	-8.1	-8.7	-9.4	-10.0
30.00	76.2	-7.4	-8.0	-8.7	-9.4	-10.1	-10.2
26.00	66.0	-8.3	-9.0	-9.7	-10.4	-11.0	-10.7
22.00	55.9	-9.6	-10.4	-11.0	-11.7	-12.2	-11.1
18.00	45.7	-10.7	-11.4	-12.0	-12.6	-13.3	-12.0
14.00	35.6	-12.3	-12.9	-13.5	-14.2	-14.9	-13.5
10.00	25.4	-14.7	-15.2	-15.8	-16.5	-17.1	-14.7
8.00	20.3	-15.8	-16.4	-17.0	-17.5	-18.1	-15.4
6.00	15.2	-17.3	-17.8	-18.3	-18.7	-19.2	-16.1
4.00	10.2	-18.6	-18.9	-19.2	-19.6	-20.2	-16.6
2.00	5.1	-19.0	-19.2	-19.6	-20.3	-20.9	-17.4
1.00	2.5	-19.0	-19.6	-20.1	-20.8	-21.6	-17.8
0.50	1.3	-19.2	-20.0	-20.6	-21.3	-22.0	-17.8
0.25	0.6	-20.4	-21.6	-22.1	-22.7	-23.3	-18.1
0.00	0.0	-21.1	-21.5	-22.1	-22.6	-23.2	-13.5

TABLE 9A (CONCLUDED)

TANK 1 TEMPERATURE DISTRIBUTION, C

APRIL 23, 1981

T/C HEIGHT		PACIFIC DAYLIGHT TIME					
IN	CM	15:00	15:10	15:20	15:30	15:40	15:50
-----	-----	-----	-----	-----	-----	-----	-----
46.00	116.8	8.4	6.6	5.5	14.9	12.1	11.5
45.50	115.6	-6.6	-5.1	-5.0	5.1	3.6	5.1
45.00	114.3	-7.6	-6.2	-6.3	2.1	1.3	3.7
44.00	111.8	-7.6	-6.4	-6.8	-0.7	-0.6	2.4
42.00	106.7	-9.1	-8.5	-7.3	-6.2	-4.0	-0.5
38.00	96.5	-9.5	-8.7	-7.5	-6.3	-4.2	-2.8
34.00	86.4	-9.9	-8.8	-7.7	-6.5	-4.4	-3.0
30.00	76.2	-10.1	-9.0	-7.7	-6.5	-4.4	-3.1
26.00	66.0	-10.3	-9.0	-7.7	-6.5	-4.6	-3.1
22.00	55.9	-10.5	-9.0	-7.7	-6.4	-4.7	-3.1
18.00	45.7	-10.8	-9.0	-7.7	-6.4	-4.6	-3.0
14.00	35.6	-11.7	-9.6	-8.0	-6.9	-5.0	-3.2
10.00	25.4	-11.2	-9.3	-7.8	-6.6	-4.7	-3.1
8.00	20.3	-11.3	-9.2	-7.7	-6.5	-4.6	-2.9
6.00	15.2	-11.3	-9.2	-7.7	-6.4	-4.6	-2.9
4.00	10.2	-11.3	-9.1	-7.7	-6.2	-4.5	-2.8
2.00	5.1	-11.4	-9.1	-7.6	-6.3	-4.6	-2.8
1.00	2.5	-11.4	-9.2	-7.6	-6.3	-4.6	-2.8
0.50	1.3	-11.4	-9.2	-7.6	-6.2	-4.6	-2.8
0.25	0.6	-11.6	-9.4	-7.8	-6.3	-4.8	-2.9
0.00	0.0	1.2	0.2	-0.7	5.1	3.8	3.7
		16:00	16:10	16:20	16:30		
		-----	-----	-----	-----		
46.00	116.8	20.0	16.7	23.0	23.0		
45.50	115.6	16.0	14.2	18.5	20.8		
45.00	114.3	14.4	13.3	17.3	19.9		
44.00	111.8	13.0	12.5	16.6	18.9		
42.00	106.7	7.0	8.9	12.8	14.6		
38.00	96.5	1.9	6.5	10.3	12.2		
34.00	86.4	-0.9	3.4	6.8	9.7		
30.00	76.2	-1.1	0.8	3.3	7.0		
26.00	66.0	-1.1	0.6	3.4	5.2		
22.00	55.9	-1.1	0.5	3.4	5.1		
18.00	45.7	-1.2	0.5	3.4	5.0		
14.00	35.6	-1.7	0.1	3.1	4.7		
10.00	25.4	-1.5	0.1	3.3	4.6		
8.00	20.3	-1.5	0.2	3.4	4.7		
6.00	15.2	-1.5	0.2	3.4	4.8		
4.00	10.2	-1.5	0.2	3.4	4.8		
2.00	5.1	-1.4	0.3	3.4	4.8		
1.00	2.5	-1.4	0.3	3.3	4.8		
0.50	1.3	-1.4	0.3	3.4	4.8		
0.25	0.6	-1.1	0.2	3.3	4.6		
0.00	0.0	7.8	7.9	9.9	8.2		

TABLE 9B

TANK 2R TEMPERATURE DISTRIBUTION, C

APRIL 23, 1981

T/C HEIGHT		PACIFIC DAYLIGHT TIME					
IN	CM	9:00	9:10	9:20	9:30	9:40	9:50
-----	-----	-----	-----	-----	-----	-----	-----
22.00	55.9	28.3	29.1	20.2	17.4	13.8	10.1
21.50	54.6	27.3	28.1	21.0	18.4	14.9	12.4
21.00	53.3	27.1	28.0	21.3	18.9	15.2	12.9
20.00	50.8	26.6	27.7	21.3	19.6	15.3	13.3
18.00	45.7	22.5	23.2	22.3	21.8	17.0	15.2
14.00	35.6	21.5	22.0	22.3	21.8	20.8	19.9
10.00	25.4	21.4	22.0	22.3	21.8	20.8	20.0
8.00	20.3	21.2	21.9	22.1	21.7	20.7	19.8
6.00	15.2	21.1	21.8	22.1	21.7	20.7	19.8
4.00	10.2	21.0	21.7	22.1	21.6	20.6	19.6
2.00	5.1	21.0	21.9	22.2	21.7	20.8	19.5
1.00	2.5	20.9	21.8	22.1	21.6	20.6	19.4
0.50	1.3	21.0	21.8	22.1	21.6	20.6	19.4
0.25	0.6	21.0	21.8	22.0	21.5	20.5	19.2
0.00	0.0	21.4	21.9	21.5	20.9	19.8	17.2
		10:00	10:10	10:20	10:30	10:40	10:50
		-----	-----	-----	-----	-----	-----
22.00	55.9	-1.8	-12.8	-19.5	-21.8	-23.4	-23.0
21.50	54.6	1.8	-8.5	-15.8	-19.2	-21.2	-21.5
21.00	53.3	2.7	-7.4	-15.0	-18.4	-20.5	-21.0
20.00	50.8	3.1	-7.1	-14.6	-17.9	-20.0	-20.5
18.00	45.7	7.5	-0.9	-9.0	-12.9	-15.8	-17.3
14.00	35.6	14.3	7.3	-0.1	-4.9	-8.4	-11.4
10.00	25.4	18.0	15.3	12.1	8.5	-1.3	-6.3
8.00	20.3	17.8	14.9	11.5	8.1	3.4	-0.7
6.00	15.2	17.7	14.5	11.0	7.4	3.2	-0.9
4.00	10.2	17.2	13.7	10.1	6.8	3.0	-1.1
2.00	5.1	16.9	13.4	10.1	6.8	3.0	-1.1
1.00	2.5	16.7	13.2	9.9	6.6	2.9	-1.2
0.50	1.3	16.4	13.0	9.8	6.5	2.9	-1.3
0.25	0.6	16.2	12.9	9.6	6.4	2.8	-1.4
0.00	0.0	12.3	8.2	5.5	2.5	1.0	-2.8

TABLE 9B (CONTINUED)

TANK 2R TEMPERATURE DISTRIBUTION, C

APRIL 23, 1981

T/C HEIGHT		PACIFIC DAYLIGHT TIME					
IN	CM	11:00	11:10	11:20	11:30	11:40	11:50
-----	-----	-----	-----	-----	-----	-----	-----
22.00	55.9	-23.1	-22.2	-20.6	-21.0	-21.4	-20.6
21.50	54.6	-21.9	-21.6	-19.7	-19.9	-20.8	-20.0
21.00	53.3	-21.4	-21.3	-19.5	-19.8	-20.6	-19.7
20.00	50.8	-21.1	-21.0	-19.3	-19.8	-20.6	-19.8
18.00	45.7	-18.3	-18.5	-17.5	-18.4	-19.6	-19.4
14.00	35.6	-14.1	-15.6	-15.6	-16.8	-18.6	-18.8
10.00	25.4	-10.7	-13.0	-13.9	-15.9	-18.1	-18.4
8.00	20.3	-9.2	-11.9	-13.3	-15.9	-18.2	-18.5
6.00	15.2	-4.9	-11.1	-12.7	-15.9	-18.4	-18.4
4.00	10.2	-4.9	-9.5	-11.8	-16.1	-18.8	-18.5
2.00	5.1	-4.9	-8.4	-11.7	-16.6	-19.0	-18.2
1.00	2.5	-5.0	-8.5	-12.0	-17.1	-19.2	-18.2
0.50	1.3	-5.0	-8.5	-11.2	-17.0	-19.2	-18.2
0.25	0.6	-5.1	-8.6	-11.2	-17.4	-19.3	-18.3
0.00	0.0	-6.3	-9.4	-11.7	-18.1	-19.3	-18.2
		12:00	12:10	12:20	12:30	12:40	12:50
		-----	-----	-----	-----	-----	-----
22.00	55.9	-24.9	-25.3	-26.4	-26.4	-25.6	-24.5
21.50	54.6	-23.6	-24.6	-25.7	-26.0	-25.4	-24.3
21.00	53.3	-23.2	-24.4	-25.4	-25.7	-25.2	-24.1
20.00	50.8	-23.1	-24.5	-25.5	-25.9	-25.3	-24.2
18.00	45.7	-21.7	-23.5	-24.2	-24.9	-24.5	-23.7
14.00	35.6	-20.2	-22.3	-23.4	-24.2	-24.4	-23.7
10.00	25.4	-19.7	-21.8	-23.0	-24.0	-24.3	-23.6
8.00	20.3	-19.8	-21.8	-23.0	-24.0	-24.3	-23.5
6.00	15.2	-19.9	-21.8	-23.0	-24.0	-24.2	-23.2
4.00	10.2	-20.3	-21.8	-23.0	-24.0	-24.0	-22.8
2.00	5.1	-20.6	-22.1	-23.2	-24.1	-23.8	-22.5
1.00	2.5	-20.8	-22.2	-23.4	-24.2	-23.8	-22.5
0.50	1.3	-20.8	-22.1	-23.4	-24.0	-23.7	-22.3
0.25	0.6	-21.0	-22.3	-23.6	-24.2	-23.7	-22.3
0.00	0.0	-21.3	-22.4	-23.7	-24.1	-23.1	-21.9

TABLE 9B (CONTINUED)

TANK 2R TEMPERATURE DISTRIBUTION, C

APRIL 23, 1981

T/C HEIGHT		PACIFIC DAYLIGHT TIME					
IN	CM	13:00	13:10	13:20	13:30	13:40	13:50
-----	-----	-----	-----	-----	-----	-----	-----
22.00	55.9	-24.8	-26.3	-25.4	-26.5	-27.9	-28.0
21.50	54.6	-24.5	-25.8	-25.3	-25.9	-27.4	-27.8
21.00	53.3	-24.2	-25.5	-25.0	-25.6	-27.0	-27.5
20.00	50.8	-24.3	-25.6	-25.2	-25.7	-27.1	-27.6
18.00	45.7	-23.7	-24.6	-24.5	-24.8	-26.0	-26.6
14.00	35.6	-23.4	-24.1	-24.4	-24.6	-25.5	-26.3
10.00	25.4	-23.2	-23.9	-24.5	-24.5	-25.3	-26.0
8.00	20.3	-23.2	-24.0	-24.5	-24.5	-25.2	-25.9
6.00	15.2	-23.0	-24.0	-24.4	-24.4	-25.2	-25.8
4.00	10.2	-22.9	-24.1	-24.3	-24.4	-25.2	-25.7
2.00	5.1	-22.9	-24.2	-24.1	-24.3	-25.2	-25.7
1.00	2.5	-22.9	-24.3	-24.2	-24.3	-25.2	-25.6
0.50	1.3	-22.8	-24.2	-24.1	-24.2	-25.1	-25.5
0.25	0.6	-23.0	-24.4	-24.2	-24.4	-25.2	-25.6
0.00	0.0	-23.2	-24.5	-24.0	-24.5	-25.2	-25.4
		14:00	14:10	14:20	14:30	14:40	14:50
		-----	-----	-----	-----	-----	-----
22.00	55.9	-27.6	-27.6	-27.9	-28.6	-29.4	-15.3
21.50	54.6	-27.3	-27.5	-27.7	-28.4	-29.1	-17.2
21.00	53.3	-27.0	-27.2	-27.3	-28.0	-28.7	-17.5
20.00	50.8	-27.2	-27.4	-27.5	-28.1	-28.9	-18.1
18.00	45.7	-26.4	-26.6	-26.7	-27.4	-28.1	-19.5
14.00	35.6	-26.2	-26.4	-26.4	-27.0	-27.6	-21.7
10.00	25.4	-26.0	-26.2	-26.2	-26.8	-27.3	-22.1
8.00	20.3	-25.9	-26.1	-26.2	-26.7	-27.2	-22.0
6.00	15.2	-25.6	-26.0	-26.0	-26.7	-27.1	-21.5
4.00	10.2	-25.4	-25.9	-25.8	-26.6	-27.0	-21.0
2.00	5.1	-25.3	-25.7	-25.7	-26.6	-27.0	-18.3
1.00	2.5	-25.2	-25.7	-25.8	-26.6	-27.0	-17.3
0.50	1.3	-25.1	-25.6	-25.7	-26.4	-26.9	-17.6
0.25	0.6	-25.2	-25.6	-25.8	-26.5	-26.9	-17.0
0.00	0.0	-25.0	-25.4	-25.8	-26.4	-26.8	-14.1

TABLE 9B (CONCLUDED)

TANK 2R TEMPERATURE DISTRIBUTION, C

APRIL 23, 1981

T/C HEIGHT		PACIFIC DAYLIGHT TIME					
IN	CM	15:00	15:10	15:20	15:30	15:40	15:50
-----	-----	-----	-----	-----	-----	-----	-----
22.00	55.9	12.6	13.2	11.9	16.0	18.2	14.2
21.50	54.6	10.3	12.0	11.4	14.8	18.8	14.1
21.00	53.3	9.3	11.8	11.6	14.6	18.9	14.4
20.00	50.8	8.4	12.1	11.4	14.3	19.0	14.2
18.00	45.7	3.5	10.4	11.1	13.5	18.6	14.8
14.00	35.6	-0.9	7.7	10.2	12.4	17.7	15.7
10.00	25.4	-2.4	6.4	9.5	12.1	17.4	16.0
8.00	20.3	-2.5	6.4	9.3	12.2	17.5	15.9
6.00	15.2	-1.7	6.8	9.3	12.5	18.0	15.7
4.00	10.2	-0.8	8.0	9.1	12.9	18.8	15.7
2.00	5.1	-1.6	8.5	8.8	13.9	19.3	15.4
1.00	2.5	-0.6	8.6	8.7	14.3	19.1	15.4
0.50	1.3	-0.1	8.5	8.2	14.7	19.2	15.5
0.25	0.6	0.0	8.8	8.2	15.1	19.2	15.5
0.00	0.0	2.7	9.6	9.7	16.7	19.0	15.5
		16:00	16:10	16:20	16:30		
		-----	-----	-----	-----		
22.00	55.9	19.6	15.9	21.0	25.5		
21.50	54.6	19.3	15.8	19.6	24.9		
21.00	53.3	19.3	16.1	19.5	24.8		
20.00	50.8	19.1	16.0	19.1	24.6		
18.00	45.7	18.5	16.2	18.6	23.8		
14.00	35.6	17.5	16.5	17.7	22.4		
10.00	25.4	17.2	16.6	17.6	22.1		
8.00	20.3	17.3	16.4	17.6	22.1		
6.00	15.2	17.7	16.3	17.8	22.4		
4.00	10.2	18.4	16.3	18.1	23.0		
2.00	5.1	19.1	16.3	19.0	24.2		
1.00	2.5	19.3	16.2	19.4	24.5		
0.50	1.3	19.5	16.4	19.7	24.7		
0.25	0.6	19.6	16.3	20.1	24.9		
0.00	0.0	19.9	16.4	21.5	25.7		

TABLE 10A

TANK 1 TEMPERATURE DISTRIBUTION, C

APRIL 30, 1981

T/C HEIGHT		PACIFIC DAYLIGHT TIME					
IN	CM	8:40	8:50	9:00	9:10	9:20	9:30
-----	-----	-----	-----	-----	-----	-----	-----
46.00	116.8	26.3	24.6	26.5	22.2	21.5	15.3
45.50	115.6	24.7	24.8	24.9	24.5	24.8	25.1
45.00	114.3	24.6	24.7	24.8	24.5	24.8	25.2
44.00	111.8	24.8	24.9	24.9	24.7	25.0	25.3
42.00	106.7	24.7	24.8	24.9	24.7	25.1	25.5
38.00	96.5	24.6	24.8	24.9	24.8	25.1	25.7
34.00	86.4	24.5	24.6	24.8	24.7	25.1	25.6
30.00	76.2	24.4	24.6	24.7	24.6	25.0	25.6
26.00	66.0	24.5	24.6	24.8	24.7	25.1	25.6
22.00	55.9	24.4	24.5	24.8	24.7	25.1	25.6
18.00	45.7	24.4	24.5	24.8	24.7	25.1	25.5
14.00	35.6	24.3	24.4	24.7	24.7	25.1	25.7
10.00	25.4	24.2	24.3	24.7	24.5	25.0	25.1
8.00	20.3	24.2	24.4	24.8	24.6	25.0	24.8
6.00	15.2	24.2	24.3	24.8	24.6	25.0	24.4
4.00	10.2	24.2	24.3	24.8	24.6	25.0	23.8
2.00	5.1	24.2	24.2	24.8	24.6	25.0	23.5
1.00	2.5	24.1	24.2	24.7	24.6	24.9	23.2
0.50	1.3	24.2	24.2	24.8	24.6	24.9	23.0
0.25	0.6	24.0	24.0	24.6	24.3	24.6	21.2
0.00	0.0	24.0	24.6	26.0	22.1	21.7	13.7
		9:40	9:50	10:00	10:10	10:20	10:30
		-----	-----	-----	-----	-----	-----
46.00	116.8	6.6	-5.0	-9.3	-10.2	-11.7	-10.9
45.50	115.6	23.9	11.9	3.4	0.2	0.7	-1.1
45.00	114.3	25.2	13.2	6.1	2.2	2.3	0.6
44.00	111.8	25.3	15.7	8.5	3.9	3.4	1.7
42.00	106.7	25.6	24.9	23.5	11.3	5.3	3.4
38.00	96.5	25.4	24.4	23.1	19.7	19.7	18.8
34.00	86.4	25.1	24.1	22.7	19.3	19.1	18.3
30.00	76.2	25.1	24.1	22.7	19.2	19.0	18.1
26.00	66.0	25.0	24.1	22.4	19.0	18.9	17.9
22.00	55.9	25.0	24.1	22.4	19.0	18.8	17.6
18.00	45.7	25.0	24.0	22.4	18.9	18.8	17.4
14.00	35.6	25.2	24.2	22.6	18.9	18.8	16.5
10.00	25.4	24.5	23.5	21.9	18.5	18.2	15.1
8.00	20.3	24.2	23.4	21.7	18.5	17.8	13.8
6.00	15.2	23.6	22.6	20.6	17.7	16.8	13.3
4.00	10.2	23.4	21.6	19.2	16.1	16.2	13.0
2.00	5.1	23.2	21.3	18.1	15.7	15.9	12.7
1.00	2.5	22.8	20.7	16.9	14.8	15.6	12.5
0.50	1.3	22.7	20.1	16.0	13.8	15.1	12.3
0.25	0.6	20.9	16.6	12.9	10.7	12.5	10.3
0.00	0.0	11.6	7.5	4.3	3.8	4.8	3.6

TABLE 10A (CONTINUED)

TANK 1 TEMPERATURE DISTRIBUTION, C

APRIL 30, 1981

T/C HEIGHT		PACIFIC DAYLIGHT TIME					
IN	CM	10:40	10:50	11:00	11:10	11:20	11:30
46.00	116.8	-10.9	-7.9	-10.9	-13.5	-15.5	-15.2
45.50	115.6	-1.9	0.3	-3.2	-5.2	-6.7	-6.9
45.00	114.3	-0.1	2.1	-1.5	-3.8	-5.2	-5.7
44.00	111.8	1.2	3.0	-0.3	-2.7	-4.5	-5.2
42.00	106.7	2.4	5.8	0.8	-0.9	-1.1	-1.8
38.00	96.5	18.5	18.5	14.8	13.2	-0.2	-1.5
34.00	86.4	18.1	17.9	13.8	12.6	11.7	11.8
30.00	76.2	17.9	17.6	13.4	12.3	11.2	11.0
26.00	66.0	17.8	17.3	13.2	12.1	11.0	10.7
22.00	55.9	17.4	16.8	13.0	12.0	10.9	10.4
18.00	45.7	16.8	16.4	12.9	12.0	10.7	10.1
14.00	35.6	15.6	15.3	12.7	11.7	10.6	9.6
10.00	25.4	13.8	13.3	12.2	11.1	10.1	7.7
8.00	20.3	12.7	12.0	11.8	10.4	9.5	7.1
6.00	15.2	12.1	10.9	10.8	9.6	8.6	6.5
4.00	10.2	11.9	10.4	9.7	9.1	8.0	5.6
2.00	5.1	11.6	10.2	9.3	9.0	7.9	4.6
1.00	2.5	11.4	9.8	8.8	8.8	7.5	3.3
0.50	1.3	11.2	9.6	8.3	8.6	7.4	2.6
0.25	0.6	9.1	7.2	6.5	7.3	5.6	-0.5
0.00	0.0	2.6	1.1	-0.8	-1.4	-2.5	-5.3
		11:40	11:50	12:00	12:10	12:20	12:30
46.00	116.8	-17.0	-16.0	-16.1	-13.0	-11.3	-12.2
45.50	115.6	-9.7	-10.9	-11.9	-10.8	-7.0	-7.8
45.00	114.3	-8.1	-9.4	-10.7	-10.5	-6.5	-7.2
44.00	111.8	-7.2	-8.7	-10.0	-9.9	-6.4	-7.0
42.00	106.7	-3.0	-6.1	-7.4	-6.0	-4.5	-5.5
38.00	96.5	-2.7	-4.4	-5.1	-4.5	-3.1	-4.5
34.00	86.4	11.4	9.9	6.6	0.8	-1.8	-4.0
30.00	76.2	10.7	9.4	6.5	5.4	4.6	4.1
26.00	66.0	10.3	8.9	6.2	5.2	4.4	4.1
22.00	55.9	9.8	8.7	5.9	5.1	4.3	4.0
18.00	45.7	9.3	8.6	5.7	5.0	4.2	3.9
14.00	35.6	9.0	8.3	5.5	4.7	4.1	3.7
10.00	25.4	8.1	7.6	4.9	4.2	3.8	3.3
8.00	20.3	7.4	6.9	4.6	3.9	3.6	3.1
6.00	15.2	6.5	6.5	4.0	3.7	2.8	2.3
4.00	10.2	5.9	6.3	3.7	3.6	2.4	2.0
2.00	5.1	5.7	6.3	3.7	3.6	2.4	1.8
1.00	2.5	5.6	6.2	3.4	3.5	2.0	1.7
0.50	1.3	5.4	6.2	3.3	3.4	1.8	1.5
0.25	0.6	4.0	5.6	1.1	2.6	0.3	-0.5
0.00	0.0	-3.7	-2.8	-4.8	-3.3	-4.0	-5.2

TABLE 10A (CONTINUED)

TANK 1 TEMPERATURE DISTRIBUTION, C

APRIL 30, 1981

T/C HEIGHT		PACIFIC DAYLIGHT TIME					
IN	CM	12:40	12:50	13:00	13:10	13:20	13:30
46.00	116.8	-10.9	-14.2	-16.6	-18.3	-21.6	-23.0
45.50	115.6	-7.3	-8.4	-10.3	-13.2	-16.1	-17.1
45.00	114.3	-6.7	-7.7	-9.3	-11.7	-15.2	-16.3
44.00	111.8	-6.7	-7.6	-9.1	-11.4	-15.0	-16.1
42.00	106.7	-5.3	-6.6	-8.1	-10.3	-13.7	-14.8
38.00	96.5	-4.2	-5.7	-7.1	-8.9	-12.5	-13.6
34.00	86.4	-3.9	-5.3	-7.0	-8.7	-11.7	-13.1
30.00	76.2	0.8	-4.1	-6.2	-8.2	-11.4	-12.3
26.00	66.0	3.6	2.8	2.5	1.4	-8.8	-11.9
22.00	55.9	3.5	3.0	2.7	1.5	-1.9	-3.0
18.00	45.7	3.4	2.9	2.6	1.2	-2.2	-3.3
14.00	35.6	3.2	2.9	2.5	1.2	-2.4	-3.3
10.00	25.4	3.0	2.3	2.1	0.7	-2.9	-3.8
8.00	20.3	2.7	2.0	2.1	0.4	-2.9	-4.0
6.00	15.2	2.3	2.0	1.5	-0.2	-3.2	-4.3
4.00	10.2	2.0	1.9	1.0	-0.4	-3.6	-4.5
2.00	5.1	1.8	2.0	0.9	-0.5	-3.8	-4.8
1.00	2.5	1.6	1.9	0.8	-0.8	-4.1	-5.2
0.50	1.3	1.4	1.8	0.6	-1.1	-4.4	-5.6
0.25	0.6	-0.2	0.4	-1.8	-3.4	-7.1	-8.1
0.00	0.0	-4.7	-5.4	-7.6	-9.0	-11.8	-13.7
		13:40	13:50	14:00	14:10	14:20	14:30
46.00	116.8	-21.3	-17.1	-13.0	-14.6	-13.7	-14.2
45.50	115.6	-17.1	-14.9	-12.9	-14.0	-12.8	-12.0
45.00	114.3	-16.2	-14.5	-12.3	-13.8	-12.6	-11.7
44.00	111.8	-16.1	-14.7	-12.4	-13.9	-12.8	-11.5
42.00	106.7	-14.9	-12.8	-11.2	-12.8	-12.0	-10.6
38.00	96.5	-13.7	-12.4	-10.4	-12.5	-11.7	-10.3
34.00	86.4	-13.0	-11.6	-9.9	-12.0	-11.5	-10.2
30.00	76.2	-12.3	-10.8	-9.1	-11.5	-11.2	-10.0
26.00	66.0	-12.4	-10.4	-8.6	-11.3	-11.0	-9.9
22.00	55.9	-4.1	-5.1	-7.9	-10.9	-10.9	-9.8
18.00	45.7	-4.2	-4.6	-4.3	-7.4	-8.5	-9.5
14.00	35.6	-4.3	-4.7	-4.6	-7.9	-8.2	-7.3
10.00	25.4	-4.6	-4.8	-4.8	-7.9	-8.2	-7.3
8.00	20.3	-4.6	-4.8	-4.9	-7.9	-8.1	-7.2
6.00	15.3	-4.7	-4.8	-4.9	-7.9	-8.1	-7.2
4.00	10.2	-4.8	-5.0	-5.0	-8.0	-8.1	-7.3
2.00	5.1	-4.9	-5.0	-5.0	-8.0	-8.0	-7.2
1.00	2.5	-5.1	-5.2	-5.2	-8.2	-8.1	-7.3
0.50	1.3	-5.5	-5.2	-5.3	-8.3	-8.1	-7.3
0.25	0.6	-8.0	-6.7	-7.3	-10.0	-8.9	-7.8
0.00	0.0	-12.1	-10.2	-9.4	-11.6	-10.9	-10.4

TABLE 10A (CONCLUDED)

TANK 1 TEMPERATURE DISTRIBUTION, C

APRIL 30, 1981

T/C HEIGHT		PACIFIC DAYLIGHT TIME					
IN	CM	14:40	14:50	15:00	15:10	15:20	15:30
46.00	116.8	-19.7	-22.7	-8.3	11.4	16.7	14.3
45.50	115.6	-16.0	-18.6	-11.2	3.7	12.1	11.3
45.00	114.3	-15.7	-18.0	-11.6	2.7	11.3	10.9
44.00	111.8	-15.1	-17.3	-12.5	0.7	10.0	10.2
42.00	106.7	-13.6	-15.2	-12.4	-2.9	5.0	7.2
38.00	96.5	-13.2	-14.6	-12.3	-3.6	3.7	6.1
34.00	86.4	-13.1	-14.7	-12.0	-4.5	2.2	4.8
30.00	76.2	-13.0	-14.5	-11.8	-5.5	0.5	3.3
26.00	66.0	-13.1	-14.9	-11.6	-6.0	-0.5	2.3
22.00	55.9	-13.2	-15.2	-11.4	-6.1	-1.4	1.3
18.00	45.7	-13.0	-15.3	-11.3	-6.8	-2.5	-0.1
14.00	35.6	-10.1	-15.2	-11.3	-7.9	-3.9	-1.9
10.00	25.4	-10.0	-10.7	-11.1	-8.4	-4.6	-3.4
8.00	20.3	-10.0	-10.7	-11.0	-8.7	-4.9	-3.6
6.00	15.2	-10.2	-10.8	-10.9	-8.7	-5.0	-3.8
4.00	10.2	-10.3	-10.9	-11.0	-8.8	-5.0	-3.9
2.00	5.1	-10.2	-10.9	-10.9	-8.8	-5.1	-3.9
1.00	2.5	-10.3	-10.9	-10.9	-8.8	-5.2	-4.0
0.50	1.3	-10.2	-11.2	-10.9	-8.6	-5.1	-3.8
0.25	0.6	-12.6	-14.2	-11.1	-9.0	-5.4	-4.1
0.00	0.0	-14.8	-18.0	-9.4	0.4	3.0	2.9
		15:40	15:50				
46.00	116.8	25.4	25.8				
45.50	115.6	19.8	22.8				
45.00	114.3	18.3	21.2				
44.00	111.8	17.0	20.6				
42.00	106.7	13.8	17.2				
38.00	96.5	12.6	15.4				
34.00	86.4	11.2	13.6				
30.00	76.2	9.6	12.1				
26.00	66.0	8.3	10.9				
22.00	55.9	7.1	9.4				
18.00	45.7	5.0	7.6				
14.00	35.6	0.3	3.9				
10.00	25.4	0.4	2.8				
8.00	20.3	0.4	2.9				
6.00	15.2	0.4	2.9				
4.00	10.2	0.4	2.9				
2.00	5.1	0.2	2.7				
1.00	2.5	0.1	2.6				
0.50	1.3	0.2	2.8				
0.25	0.6	0.0	2.6				
0.00	0.0	7.6	6.2				

TABLE 10B

TANK 2R TEMPERATURE DISTRIBUTION, C

APRIL 30, 1981

T/C HEIGHT		PACIFIC DAYLIGHT TIME					
IN	CM	8:40	8:50	9:00	9:10	9:20	9:30
-----	-----	-----	-----	-----	-----	-----	-----
22.00	55.9	26.2	25.5	25.4	22.4	21.3	15.5
21.50	54.6	25.4	25.0	24.5	23.5	23.1	21.6
21.00	53.3	24.9	24.9	24.4	23.6	23.7	23.5
20.00	50.8	23.9	24.3	24.3	23.6	23.7	23.6
18.00	45.7	23.7	24.1	24.3	23.7	23.7	23.7
14.00	35.6	23.6	23.7	24.1	23.7	23.8	23.7
10.00	25.4	23.5	23.6	24.0	23.7	23.7	23.6
8.00	20.3	23.4	23.5	23.9	23.6	23.6	23.4
6.00	15.2	23.3	23.5	23.9	23.6	23.6	23.3
4.00	10.2	23.3	23.5	23.9	23.5	23.6	22.5
2.00	5.1	23.5	23.6	24.0	23.6	23.7	21.7
1.00	2.5	23.4	23.6	24.0	23.6	23.6	21.4
0.50	1.3	23.4	23.6	24.1	23.6	23.6	20.7
0.25	0.6	23.4	23.6	24.1	23.5	23.4	19.9
0.00	0.0	23.6	24.0	24.8	23.0	22.5	16.1
		9:40	9:50	10:00	10:10	10:20	10:30
		-----	-----	-----	-----	-----	-----
22.00	55.9	10.2	4.8	2.0	0.2	-0.8	-0.4
21.50	54.6	17.3	12.5	9.5	7.1	5.7	4.8
21.00	53.3	21.3	17.2	14.0	8.9	7.1	6.2
20.00	50.8	22.1	20.1	17.8	13.4	12.4	10.6
18.00	45.7	22.2	20.2	17.8	13.4	12.4	10.8
14.00	35.6	22.2	20.2	18.0	13.5	12.5	10.7
10.00	25.4	22.0	19.9	17.8	13.2	12.2	10.5
8.00	20.3	21.7	19.5	17.3	13.0	11.9	10.3
6.00	15.2	21.6	19.5	17.0	12.8	11.8	10.1
4.00	10.2	20.8	19.0	16.6	12.2	11.1	9.2
2.00	5.1	20.2	16.9	13.9	10.4	9.9	8.4
1.00	2.5	19.9	15.7	12.5	8.6	9.0	7.7
0.50	1.3	19.5	14.1	10.1	6.8	7.7	6.7
0.25	0.6	18.9	12.5	7.7	5.4	6.7	5.8
0.00	0.0	14.3	8.3	4.0	2.6	4.1	3.3

TABLE 10B (CONTINUED)

TANK 2R TEMPERATURE DISTRIBUTION, C

APRIL 30, 1981

T/C HEIGHT		PACIFIC DAYLIGHT TIME					
IN	CM	10:40	10:50	11:00	11:10	11:20	11:30
-----	-----	-----	-----	-----	-----	-----	-----
22.00	55.9	-0.5	-1.4	-4.4	-5.0	-8.5	-9.9
21.50	54.6	4.9	3.6	0.3	-0.1	-3.2	-4.7
21.00	53.3	6.7	5.7	4.4	2.7	0.1	-3.2
20.00	50.8	9.9	9.1	5.0	3.3	1.6	0.9
18.00	45.7	9.9	9.1	5.0	3.3	1.6	1.0
14.00	35.6	10.0	9.1	5.1	3.3	1.6	1.1
10.00	25.4	9.8	8.8	5.0	3.2	1.5	0.9
8.00	20.3	9.5	8.6	4.7	3.1	1.3	0.7
6.00	15.2	9.3	8.3	4.5	2.8	1.2	0.6
4.00	10.2	8.7	7.6	3.7	1.9	0.2	-0.1
2.00	5.1	7.0	6.5	2.8	1.6	0.1	-1.5
1.00	2.5	5.3	5.8	2.3	1.4	-0.1	-3.9
0.50	1.3	3.8	4.5	1.2	0.9	-0.6	-5.7
0.25	0.6	2.5	3.1	-0.1	0.1	-1.3	-7.2
0.00	0.0	0.6	1.1	-2.9	-3.4	-4.9	-8.7
		11:40	11:50	12:00	12:10	12:20	12:30
		-----	-----	-----	-----	-----	-----
22.00	55.9	-8.1	-8.2	-11.2	-10.3	-10.2	-10.9
21.50	54.6	-3.2	-4.1	-8.0	-7.8	-8.2	-8.6
21.00	53.3	-0.6	-1.8	-5.5	-6.0	-6.4	-6.9
20.00	50.8	0.5	-1.2	-4.0	-5.2	-5.7	-5.9
18.00	45.7	0.5	-1.2	-4.0	-5.1	-5.7	-5.9
14.00	35.6	0.5	-1.0	-4.0	-5.0	-5.6	-5.7
10.00	25.4	0.3	-1.2	-4.1	-5.1	-5.7	-5.9
8.00	20.3	0.0	-1.3	-4.3	-5.2	-5.7	-5.9
6.00	15.2	-0.4	-1.9	-4.7	-5.4	-5.9	-6.2
4.00	10.2	-1.1	-2.5	-5.2	-5.7	-6.4	-6.6
2.00	5.1	-1.0	-2.4	-5.2	-5.6	-6.4	-6.7
1.00	2.5	-1.2	-2.6	-5.3	-5.7	-6.5	-6.9
0.50	1.3	-1.7	-2.7	-5.6	-5.9	-6.7	-7.3
0.25	0.6	-2.1	-3.1	-6.2	-6.4	-7.3	-7.9
0.00	0.0	-5.3	-6.1	-8.5	-8.0	-8.4	-9.5

TABLE 10B (CONTINUED)

TANK 2R TEMPERATURE DISTRIBUTION, C

APRIL 30, 1981

T/C HEIGHT		PACIFIC DAYLIGHT TIME					
IN	CM	12:40	12:50	13:00	13:10	13:20	13:30
-----	-----	-----	-----	-----	-----	-----	-----
22.00	55.9	-10.6	-12.4	-13.7	-14.4	-18.0	-19.5
21.50	54.6	-8.3	-9.6	-10.4	-11.5	-14.7	-15.8
21.00	53.3	-6.4	-7.9	-8.4	-8.3	-12.5	-14.1
20.00	50.8	-6.1	-6.6	-6.5	-7.5	-10.9	-11.9
18.00	45.7	-6.0	-6.6	-6.4	-7.5	-10.9	-11.9
14.00	35.6	-5.9	-6.5	-6.3	-7.3	-10.9	-11.7
10.00	25.4	-6.0	-6.6	-6.4	-7.4	-10.9	-11.9
8.00	20.3	-6.1	-6.7	-6.6	-7.7	-11.0	-12.0
6.00	15.2	-6.2	-6.7	-6.7	-7.8	-11.1	-12.3
4.00	10.2	-6.7	-6.9	-7.3	-8.3	-11.6	-12.6
2.00	5.1	-6.6	-6.8	-7.4	-9.0	-11.7	-12.6
1.00	2.5	-6.7	-6.8	-7.5	-9.2	-11.8	-12.6
0.50	1.3	-6.9	-6.9	-7.8	-9.8	-12.1	-12.9
0.25	0.6	-7.5	-7.1	-8.5	-11.2	-12.7	-13.4
0.00	0.0	-8.9	-8.9	-11.2	-12.9	-15.0	-16.1
		13:40	13:50	14:00	14:10	14:20	14:30
		-----	-----	-----	-----	-----	-----
22.00	55.9	-18.4	-15.6	-14.1	-16.5	-15.2	-14.6
21.50	54.6	-15.5	-14.1	-13.5	-15.6	-14.7	-13.5
21.00	53.3	-14.0	-13.0	-12.5	-15.0	-14.4	-13.1
20.00	50.8	-12.5	-12.2	-11.5	-14.5	-14.4	-13.1
18.00	45.7	-12.4	-12.1	-11.5	-14.5	-14.3	-13.0
14.00	35.6	-12.2	-12.0	-11.3	-14.4	-14.3	-12.9
10.00	25.4	-12.3	-12.2	-11.4	-14.4	-14.3	-12.9
8.00	20.3	-12.4	-12.4	-11.6	-14.5	-14.4	-13.0
6.00	15.2	-12.5	-12.5	-11.8	-14.6	-14.4	-13.1
4.00	10.2	-12.7	-12.5	-11.9	-14.6	-14.4	-13.2
2.00	5.1	-12.8	-12.4	-12.0	-14.5	-14.3	-13.1
1.00	2.5	-12.8	-12.4	-11.8	-14.5	-14.3	-13.1
0.50	1.3	-13.1	-12.5	-11.9	-14.6	-14.3	-13.2
0.25	0.6	-13.6	-12.8	-12.7	-14.7	-14.4	-13.6
0.00	0.0	-15.5	-14.0	-12.8	-15.0	-14.5	-14.2

TABLE 10B (CONCLUDED)

TANK 2R TEMPERATURE DISTRIBUTION, C

APRIL 30, 1981

T/C HEIGHT		PACIFIC DAYLIGHT TIME					
IN	CM	14:40	14:50	15:00	15:10	15:20	15:30
-----	-----	-----	-----	-----	-----	-----	-----
22.00	55.9	-19.0	-21.9	-12.1	7.2	14.4	12.3
21.50	54.6	-17.1	-19.0	-13.9	3.6	12.6	10.8
21.00	53.3	-15.7	-17.1	-14.0	3.5	12.8	11.1
20.00	50.8	-15.3	-15.5	-14.3	2.4	12.2	10.5
18.00	45.7	-15.3	-15.4	-14.5	-1.8	7.5	7.1
14.00	35.6	-15.2	-15.2	-14.9	-9.1	-2.1	0.6
10.00	25.4	-15.2	-15.3	-14.9	-11.2	-6.7	-4.9
8.00	20.3	-15.3	-15.5	-15.0	-11.4	-7.1	-5.2
6.00	15.2	-15.3	-15.5	-15.0	-11.5	-7.6	-5.5
4.00	10.2	-15.4	-15.9	-14.9	-11.5	-7.6	-5.4
2.00	5.1	-15.4	-16.5	-14.7	-11.5	-7.5	-5.3
1.00	2.5	-15.6	-17.4	-14.8	-11.2	-7.4	-5.1
0.50	1.3	-16.1	-18.3	-14.6	-11.0	-7.2	-5.0
0.25	0.6	-16.6	-19.1	-14.6	-11.5	-7.7	-5.5
0.00	0.0	-17.8	-20.4	-13.0	-6.9	-4.1	-2.9
		15:40	15:50				
		-----	-----				
22.00	55.9	22.1	27.4				
21.50	54.6	18.4	25.5				
21.00	53.3	18.6	25.4				
20.00	50.8	17.8	24.4				
18.00	45.7	13.8	19.8				
14.00	35.6	7.6	12.0				
10.00	25.4	-1.3	5.0				
8.00	20.3	-1.4	2.2				
6.00	15.2	-1.7	1.9				
4.00	10.2	-1.7	2.0				
2.00	5.1	-1.5	2.2				
1.00	2.5	-1.3	2.3				
0.50	1.3	-1.2	2.3				
0.25	0.6	-1.7	2.2				
0.00	0.0	0.4	3.3				

TABLE 11A

TANK 1 TEMPERATURE DISTRIBUTION, C

JUNE 21, 1981

T/C HEIGHT		PACIFIC DAYLIGHT TIME					
IN	CM	7:00	7:10	7:20	7:30	7:40	7:50
-----	-----	-----	-----	-----	-----	-----	-----
46.00	116.8	28.6	28.3	29.7	23.7	19.9	15.1
45.50	115.6	28.3	28.5	28.9	28.4	28.6	27.8
45.00	114.3	28.9	28.4	28.8	28.4	28.6	27.9
44.00	111.8	29.2	28.6	28.9	28.6	28.5	28.0
42.00	106.7	29.1	28.6	29.0	28.8	29.0	28.5
38.00	96.5	29.1	28.6	29.0	28.8	28.9	28.1
34.00	86.4	29.1	28.5	28.8	28.7	28.8	27.9
30.00	76.2	29.1	28.4	28.7	28.7	28.7	27.7
26.00	66.0	29.1	28.5	28.9	28.7	28.7	27.7
22.00	55.9	29.0	28.4	28.8	28.7	28.6	27.6
18.00	45.7	29.1	28.5	28.8	28.8	28.6	27.6
14.00	35.6	29.0	28.4	28.7	28.5	28.5	27.5
10.00	25.4	28.9	28.4	28.7	28.6	28.3	27.2
8.00	20.3	29.0	28.4	28.9	28.6	28.3	27.2
6.00	15.2	28.8	28.5	28.8	28.6	27.9	26.8
4.00	10.2	28.7	28.4	28.8	28.5	27.1	25.5
2.00	5.1	28.6	28.5	28.9	28.6	26.2	23.5
1.00	2.5	28.4	28.4	28.8	28.5	24.7	21.4
0.50	1.3	28.6	28.4	28.8	28.6	24.2	20.8
0.25	0.6	28.1	28.2	28.7	28.3	22.2	17.9
0.00	0.0	--	--	--	--	--	--
		7:54	8:10	8:20	8:30	8:40	8:50
		-----	-----	-----	-----	-----	-----
46.00	116.8	13.1	-1.5	-4.6	-8.6	-8.3	-9.8
45.50	115.6	29.4	15.3	11.6	6.4	2.5	1.0
45.00	114.3	29.7	18.0	13.7	7.9	4.7	2.5
44.00	111.8	29.7	24.6	15.1	10.4	7.1	3.9
42.00	106.7	30.1	27.8	26.7	24.0	21.8	5.6
38.00	96.5	29.5	27.3	26.1	23.3	23.0	21.2
34.00	86.4	29.2	26.8	25.5	22.7	22.3	20.2
30.00	76.2	29.1	26.6	25.3	22.4	22.1	19.9
26.00	66.0	29.1	26.6	25.1	22.2	21.9	19.7
22.00	55.9	28.9	26.4	25.0	22.1	21.7	19.5
18.00	45.7	28.9	26.3	25.0	22.1	21.6	19.4
14.00	35.6	29.0	26.2	25.0	21.9	21.6	19.3
10.00	25.4	28.6	25.7	24.2	21.2	20.8	18.7
8.00	20.3	28.6	25.3	23.9	21.2	20.7	18.3
6.00	15.2	28.1	24.4	22.5	19.8	19.2	17.1
4.00	10.2	26.5	23.4	21.1	17.9	17.5	15.6
2.00	5.1	23.3	21.7	19.9	16.0	16.0	15.0
1.00	2.5	21.4	20.9	18.9	13.9	14.6	14.3
0.50	1.3	20.7	20.1	18.2	13.1	14.0	13.8
0.25	0.6	18.1	18.1	15.9	10.0	11.3	11.7
0.00	0.0	--	--	--	--	--	--

TABLE 11A (CONTINUED)

TANK 1 TEMPERATURE DISTRIBUTION, C

JUNE 21, 1981

T/C HEIGHT		PACIFIC DAYLIGHT TIME					
IN	CM	9:00	9:10	9:20	9:30	9:39	9:50
46.00	116.8	-10.3	-10.7	-11.1	-11.5	-11.1	-11.3
45.50	115.6	0.8	-0.9	-0.5	-0.4	-0.3	-1.3
45.00	114.3	2.1	0.7	0.7	0.4	0.6	-0.4
44.00	111.8	2.9	1.6	0.9	0.3	0.3	-0.5
42.00	106.7	5.1	5.1	4.5	3.2	3.3	1.9
38.00	96.5	20.1	19.9	9.6	3.7	3.9	2.9
34.00	86.4	19.4	19.4	18.5	16.9	16.8	15.5
30.00	76.2	19.0	18.7	17.5	16.3	15.8	14.7
26.00	66.0	18.7	18.3	17.1	15.7	15.2	13.9
22.00	55.9	18.5	17.9	16.7	15.2	14.6	--
18.00	45.7	18.3	17.8	16.5	15.0	14.4	12.9
14.00	35.6	18.2	17.5	16.3	14.7	14.2	12.4
10.00	25.4	17.7	16.9	15.6	14.2	13.7	12.0
8.00	20.3	17.5	16.8	15.5	14.0	13.6	11.8
6.00	15.2	16.2	15.9	14.8	13.5	13.1	11.3
4.00	10.2	14.5	13.8	12.7	11.6	11.2	9.9
2.00	5.1	11.6	10.9	10.3	9.6	8.6	7.6
1.00	2.5	9.6	8.5	8.0	7.5	6.4	5.6
0.50	1.3	8.7	7.5	7.2	6.6	5.6	4.7
0.25	0.6	5.5	4.5	3.6	3.1	1.9	1.6
0.00	0.0	--	--	--	--	--	--
		10:00	10:10	10:20	10:30	10:40	10:50
46.00	116.8	-11.3	-10.9	-10.0	-10.9	-11.3	-13.7
45.50	115.6	-1.9	-2.3	-2.8	-3.8	-5.7	-8.1
45.00	114.3	-1.1	-1.3	-1.8	-3.1	-4.4	-7.5
44.00	111.8	-1.5	-1.8	-1.9	-3.4	-4.3	-7.4
42.00	106.7	0.9	0.4	0.3	-1.7	-3.0	-6.2
38.00	96.5	1.9	1.3	1.3	-0.4	-1.6	-5.3
34.00	86.4	5.4	2.2	2.2	0.0	-1.3	-4.7
30.00	76.2	13.4	12.6	12.8	9.7	0.7	-3.7
26.00	66.0	12.4	11.7	11.8	10.3	9.1	6.0
22.00	55.9	11.7	11.0	11.3	9.8	8.7	5.8
18.00	45.7	11.5	10.7	10.9	9.5	8.5	5.5
14.00	35.6	11.1	10.3	10.6	9.2	8.2	5.3
10.00	25.4	10.7	10.0	10.1	8.8	7.7	4.8
8.00	20.3	10.6	9.9	10.0	8.7	7.5	4.5
6.00	15.2	10.1	9.3	9.6	8.1	7.0	3.8
4.00	10.2	8.9	8.0	8.3	7.3	6.3	3.2
2.00	5.1	6.4	6.3	6.6	5.9	5.2	2.6
1.00	2.5	4.5	4.8	5.0	4.3	4.1	2.1
0.50	1.3	3.7	4.2	4.1	3.5	3.6	1.8
0.25	0.6	0.6	0.6	0.3	0.1	0.6	0.0
0.00	0.0	--	--	--	--	--	--

TABLE 11A (CONTINUED)

TANK 1 TEMPERATURE DISTRIBUTION, C

JUNE 21, 1981

T/C HEIGHT		PACIFIC DAYLIGHT TIME					
IN	CM	11:00	11:10	11:20	11:30	11:40	11:50
46.00	116.8	-12.0	-10.3	-10.0	-15.2	-18.2	-17.4
45.50	115.6	-7.3	-6.8	-6.7	-9.6	-12.4	-12.8
45.00	114.3	-6.6	-6.0	-6.0	-8.6	-11.3	-12.2
44.00	111.8	-6.5	-6.0	-5.9	-8.0	-10.7	-11.8
42.00	106.7	-5.3	-4.8	-4.9	-6.7	-8.4	-9.4
38.00	96.5	-4.3	-3.8	-4.0	-5.7	-7.3	-8.1
34.00	86.4	-3.8	-3.2	-3.4	-5.3	-6.8	-7.5
30.00	76.2	-3.0	-2.7	-2.9	-4.9	-6.2	-7.1
26.00	66.0	6.2	-2.1	-2.5	-4.9	-5.9	-6.8
22.00	55.9	5.9	5.4	4.1	2.7	-5.5	-6.3
18.00	45.7	5.7	5.1	3.9	3.0	2.0	0.1
14.00	35.6	5.4	4.8	3.7	2.9	1.6	0.4
10.00	25.4	5.2	4.5	3.5	2.7	1.1	0.1
8.00	20.3	5.1	4.2	3.3	2.5	0.9	0.0
6.00	15.2	4.4	3.8	3.1	2.3	0.6	-0.3
4.00	10.2	3.9	3.3	2.8	1.4	0.1	-0.7
2.00	5.1	3.5	2.5	2.4	0.9	-0.2	-0.8
1.00	2.5	3.2	1.1	2.0	0.1	-1.2	-1.4
0.50	1.3	2.9	0.4	1.7	-0.7	-2.1	-1.7
0.25	0.6	0.5	-2.5	-0.1	-3.5	-5.2	-4.4
0.00	0.0	--	--	--	--	--	--
		12:00	12:10	12:18	12:30	12:40	12:50
46.00	116.8	-18.1	-18.0	-18.2	--	--	-21.5
45.50	115.6	-13.8	-14.1	-14.3	--	--	-18.0
45.00	114.3	-13.0	-13.5	-13.7	--	--	-17.6
44.00	111.8	-12.6	-13.1	-13.3	--	--	-17.4
42.00	106.7	-10.1	-10.9	-11.2	--	--	-16.0
38.00	96.5	-9.5	-10.5	-10.8	--	--	-15.5
34.00	86.4	-8.8	-10.1	-10.4	--	--	-15.3
30.00	76.2	-8.6	-9.8	-10.1	--	--	-15.2
26.00	66.0	-8.5	-9.7	-10.3	--	--	-15.5
22.00	55.9	-8.3	-9.5	-10.4	--	--	-15.9
18.00	45.7	-5.4	-8.8	-10.0	--	--	-16.0
14.00	35.6	-1.4	-2.5	-6.6	--	--	-16.1
10.00	25.4	-1.9	-2.9	-3.4	--	--	-15.3
8.00	20.3	-2.1	-3.1	-3.7	--	--	-15.3
6.00	15.2	-2.1	-3.2	-3.9	--	--	-13.3
4.00	10.2	-2.2	-3.5	-4.1	--	--	-10.7
2.00	5.1	-2.2	-3.6	-4.2	--	--	-10.8
1.00	2.5	-2.3	-4.1	-4.8	--	--	-10.9
0.50	1.3	-2.3	-4.6	-5.4	--	--	-11.0
0.25	0.6	-4.1	-7.7	-8.9	--	--	-13.0
0.00	0.0	--	--	--	--	--	--

TABLE 11A (CONCLUDED)

TANK 1 TEMPERATURE DISTRIBUTION, C

JUNE 21, 1981

T/C HEIGHT		PACIFIC DAYLIGHT TIME				
IN	CM	13:00	13:10	13:20	13:30	13:40
-----	-----	-----	-----	-----	-----	-----
46.00	116.8	-21.3	-14.1	11.5	21.4	25.9
45.50	115.6	-17.8	-14.2	4.2	15.5	21.1
45.00	114.3	-17.6	-14.7	2.1	14.0	19.5
44.00	111.8	-17.6	-15.1	-0.3	12.5	18.4
42.00	106.7	-16.4	-14.2	-4.9	7.9	14.2
38.00	96.5	-16.1	-13.9	-6.0	6.4	11.9
34.00	86.4	-16.0	-13.4	-6.9	5.2	10.3
30.00	76.2	-15.9	-13.4	-8.1	3.3	8.3
26.00	66.0	-16.3	-13.1	-8.4	2.2	7.1
22.00	55.9	-16.7	-12.9	-8.5	1.4	5.8
18.00	45.7	-16.8	-13.2	-9.1	-0.7	4.2
14.00	35.6	-16.9	-13.5	-10.3	-2.0	1.7
10.00	25.4	-15.8	-13.5	-10.9	-5.1	1.5
8.00	20.3	-15.2	-13.5	-10.1	-5.2	1.6
6.00	15.2	-11.3	-13.6	-10.7	-5.2	1.6
4.00	10.2	-11.8	-13.6	-10.9	-5.2	1.6
2.00	5.1	-12.0	-13.4	-10.9	-5.1	1.6
1.00	2.5	-12.6	-13.5	-10.9	-5.0	1.5
0.50	1.3	-13.0	-13.4	-10.9	-4.8	1.6
0.25	0.6	-15.2	-13.6	-11.0	-4.6	1.1
0.00	0.0	--	--	--	--	--

TABLE 11B

TANK 2R TEMPERATURE DISTRIBUTION, C

JUNE 21, 1981

T/C HEIGHT		PACIFIC DAYLIGHT TIME					
IN	CM	7:00	7:10	7:20	7:30	7:40	7:50
-----	-----	-----	-----	-----	-----	-----	-----
22.00	55.9	27.2	27.0	28.1	23.1	19.0	13.0
21.50	54.6	26.9	26.9	27.5	25.3	24.0	19.9
21.00	53.3	27.5	27.0	27.6	27.0	26.7	21.2
20.00	50.8	27.8	27.0	27.6	27.2	26.7	25.2
18.00	45.7	27.7	26.9	27.6	27.2	26.6	25.3
14.00	35.6	27.8	27.0	27.5	27.4	26.9	25.5
10.00	25.4	27.9	27.0	27.5	27.3	26.7	25.1
8.00	20.3	27.7	26.9	27.4	27.1	26.6	24.9
6.00	15.2	27.5	26.9	27.4	27.1	26.4	24.8
4.00	10.2	27.6	26.9	27.4	27.0	26.2	24.5
2.00	5.1	27.4	27.0	27.6	27.1	24.5	22.4
1.00	2.5	27.6	27.0	27.5	27.1	22.8	20.4
0.50	1.3	27.7	27.0	27.6	27.0	20.8	18.3
0.25	0.6	27.0	27.0	27.6	26.9	19.4	17.0
0.00	0.0	27.4	27.1	28.1	25.7	18.1	14.9
		7:54	8:10	8:20	8:30	8:40	8:50
		-----	-----	-----	-----	-----	-----
22.00	55.9	11.3	3.6	2.2	-0.7	-0.7	-3.2
21.50	54.6	18.5	10.5	8.4	6.1	5.1	2.5
21.00	53.3	20.0	12.3	10.5	7.8	7.1	4.2
20.00	50.8	26.5	21.4	19.0	16.1	15.1	11.8
18.00	45.7	26.7	22.7	20.8	16.7	15.7	12.2
14.00	35.6	26.8	22.6	20.8	16.6	15.6	12.1
10.00	25.4	26.4	22.2	20.4	16.2	15.1	11.7
8.00	20.3	26.1	21.7	19.8	15.8	14.5	11.4
6.00	15.2	26.0	21.5	19.4	15.4	14.2	11.0
4.00	10.2	25.4	20.2	17.9	14.7	13.2	9.8
2.00	5.1	23.1	19.2	16.4	12.5	11.1	9.0
1.00	2.5	21.7	18.9	15.8	10.6	9.9	8.5
0.50	1.3	19.9	18.1	14.3	8.6	7.8	7.6
0.25	0.6	18.2	17.4	12.2	6.6	5.9	6.8
0.00	0.0	14.8	12.2	8.5	3.8	3.2	3.4

TABLE 11B (CONTINUED)

TANK 2R TEMPERATURE DISTRIBUTION, C

JUNE 21, 1981

T/C HEIGHT		PACIFIC DAYLIGHT TIME					
IN	CM	9:00	9:10	9:20	9:30	9:39	9:50
-----	-----	-----	-----	-----	-----	-----	-----
22.00	55.9	-3.5	-5.0	-6.3	-7.3	-7.6	-8.2
21.50	54.6	2.3	0.8	-0.6	-1.6	-2.5	-3.5
21.00	53.3	3.7	2.2	0.9	0.0	-1.1	-2.2
20.00	50.8	10.2	9.5	7.8	5.8	5.1	3.5
18.00	45.7	10.4	9.7	8.1	6.0	5.2	3.7
14.00	35.6	10.3	9.5	7.9	5.8	5.0	3.4
10.00	25.4	9.9	8.9	7.4	5.2	4.4	2.8
8.00	20.3	9.6	8.6	6.9	4.9	4.0	2.5
6.00	15.2	9.4	8.3	6.7	4.6	3.8	2.2
4.00	10.2	8.7	7.5	6.0	4.1	3.0	1.4
2.00	5.1	7.0	6.0	4.0	2.2	1.6	0.3
1.00	2.5	5.0	4.1	2.6	0.4	0.1	-0.7
0.50	1.3	3.0	2.3	0.8	-1.8	-1.5	-1.8
0.25	0.6	1.5	1.1	-0.5	-3.3	-2.5	-2.9
0.00	0.0	-0.7	-1.7	-2.8	-5.0	-4.7	-4.9
		10:00	10:10	10:20	10:30	10:40	10:50
		-----	-----	-----	-----	-----	-----
22.00	55.9	-9.0	-9.0	-8.3	-9.4	-9.5	-12.2
21.50	54.6	-4.7	-5.2	-4.8	-6.0	-6.8	-9.4
21.00	53.3	-3.6	-4.2	-3.6	-4.9	-5.3	-8.4
20.00	50.8	1.9	0.9	0.7	-0.7	-1.4	-5.1
18.00	45.7	2.1	1.0	0.8	-0.5	-1.4	-4.9
14.00	35.6	1.8	0.8	0.7	-0.6	-1.4	-5.1
10.00	25.4	1.3	0.2	0.2	-1.1	-1.7	-5.3
8.00	20.3	1.0	-0.0	-0.0	-1.4	-2.2	-5.5
6.00	15.2	0.7	-0.3	-0.3	-1.6	-2.6	-5.7
4.00	10.2	0.0	-1.0	-0.9	-2.2	-3.3	-6.7
2.00	5.1	-1.3	-2.1	-2.0	-3.4	-3.8	-6.7
1.00	2.5	-2.6	-3.0	-3.3	-4.7	-3.9	-6.9
0.50	1.3	-4.0	-3.9	-4.4	-5.8	-4.5	-7.4
0.25	0.6	-5.1	-5.0	-5.3	-6.6	-5.7	-7.9
0.00	0.0	-6.7	-6.5	-6.5	-7.8	-7.4	-9.8

TABLE 11B (CONTINUED)

TANK 2R TEMPERATURE DISTRIBUTION, C

JUNE 21, 1981

T/C HEIGHT		PACIFIC DAYLIGHT TIME					
IN	CM	11:00	11:10	11:20	11:30	11:40	11:50
-----	-----	-----	-----	-----	-----	-----	-----
22.00	55.9	-11.3	-10.5	-10.6	-13.7	-15.5	-15.8
21.50	54.6	-8.8	-8.5	-8.7	-10.9	-12.4	-12.9
21.00	53.3	-8.0	-7.7	-8.2	-10.2	-11.5	-11.4
20.00	50.8	-4.8	-5.1	-5.8	-6.8	-7.8	-8.6
18.00	45.7	-4.7	-5.0	-5.7	-6.6	-7.6	-8.5
14.00	35.6	-4.5	-5.0	-5.7	-6.5	-7.6	-8.2
10.00	25.4	-4.7	-5.2	-5.8	-6.6	-7.7	-8.4
8.00	20.3	-5.0	-5.4	-6.0	-6.8	-7.9	-8.5
6.00	15.2	-5.1	-5.5	-6.2	-6.9	-8.1	-8.6
4.00	10.2	-5.7	-6.2	-6.7	-7.5	-8.9	-8.9
2.00	5.1	-6.0	-6.5	-6.6	-7.7	-9.2	-9.4
1.00	2.5	-6.5	-6.9	-6.8	-8.0	-9.5	-9.8
0.50	1.3	-7.0	-7.4	-7.1	-8.5	-10.1	-10.4
0.25	0.6	-7.5	-8.1	-7.5	-9.2	-10.9	-11.0
0.00	0.0	-8.9	-9.1	-8.4	-11.0	-12.9	-12.6
		12:00	12:10	12:18	12:30	12:40	12:50
		-----	-----	-----	-----	-----	-----
22.00	55.9	-15.9	-16.7	-17.3	--	--	-21.1
21.50	54.6	-13.3	-14.2	-14.7	--	--	-18.8
21.00	53.3	-12.5	-13.4	-13.9	--	--	-18.0
20.00	50.8	-9.6	-10.3	-10.4	--	--	-14.7
18.00	45.7	-9.4	-10.2	-10.3	--	--	-14.6
14.00	35.6	-9.3	-10.0	-10.2	--	--	-14.6
10.00	25.4	-9.4	-10.1	-10.4	--	--	-14.8
8.00	20.3	-9.7	-10.3	-10.6	--	--	-14.9
6.00	15.2	-9.8	-10.4	-10.7	--	--	-15.1
4.00	10.2	-10.1	-10.9	-11.3	--	--	-15.8
2.00	5.1	-10.0	-11.3	-11.8	--	--	-15.9
1.00	2.5	-10.1	-11.8	-12.2	--	--	-16.0
0.50	1.3	-10.4	-12.5	-12.8	--	--	-16.5
0.25	0.6	-10.9	-13.2	-13.8	--	--	-17.2
0.00	0.0	-12.8	-14.7	-15.2	--	--	-18.7

TABLE 11B (CONCLUDED)

TANK 2R TEMPERATURE DISTRIBUTION, C

JUNE 21, 1981

T/C HEIGHT		PACIFIC DAYLIGHT TIME				
IN	CM	13:00	13:10	13:20	13:30	13:40
-----	-----	-----	-----	-----	-----	-----
22.00	55.9	-20.8	-15.2	6.7	17.4	23.4
21.50	54.6	-18.7	-15.5	3.3	14.9	20.5
21.00	53.3	-18.0	-15.4	2.8	14.6	20.1
20.00	50.8	-15.0	-15.4	1.8	13.8	18.9
18.00	45.7	-14.9	-15.4	-2.9	9.4	14.0
14.00	35.6	-14.9	-15.3	-13.5	2.0	5.5
10.00	25.4	-15.0	-15.3	-13.6	-4.1	0.4
8.00	20.3	-15.2	-15.4	-13.5	-6.6	-0.6
6.00	15.2	-15.3	-15.5	-13.5	-7.0	-0.7
4.00	10.2	-15.8	-15.8	-13.4	-7.2	-0.7
2.00	5.1	-16.0	-15.7	-13.2	-6.7	-0.3
1.00	2.5	-16.1	-15.7	-13.2	-6.7	-0.4
0.50	1.3	-16.6	-15.8	-13.0	-6.4	-0.4
0.25	0.6	-17.3	-16.1	-12.7	-6.4	-0.4
0.00	0.0	-18.6	-14.8	-8.6	-2.2	0.8

TABLE 12A

TANK 1 TEMPERATURE DISTRIBUTION, C

MARCH 9, 1983

T/C HEIGHT		PACIFIC DAYLIGHT TIME					
IN	CM	10:20	10:30	10:40	10:50	11:00	11:10
46.00	116.8	4.1	1.6	-4.8	-12.6	-17.6	-20.8
45.50	115.6	12.9	12.3	10.6	1.1	-5.8	-11.6
45.00	114.3	12.8	12.1	10.7	9.5	-2.9	-8.9
44.00	111.8	13.0	12.2	11.0	9.8	-1.8	-6.4
42.00	106.7	13.7	12.8	11.4	9.8	8.5	7.5
38.00	96.5	13.3	12.0	10.5	9.1	7.7	7.3
34.00	86.4	12.9	11.6	10.2	8.7	7.3	6.8
30.00	76.2	12.9	11.6	10.1	8.6	7.2	6.9
26.00	66.0	12.9	11.4	10.0	8.6	7.1	6.5
22.00	55.9	12.8	11.3	9.9	8.3	6.9	6.4
18.00	45.7	12.7	11.2	9.8	8.2	6.8	6.4
14.00	35.6	12.6	11.3	9.8	8.1	6.8	6.4
10.00	25.4	12.2	10.8	9.3	7.7	6.0	5.4
8.00	20.3	12.2	10.7	9.1	7.5	5.9	4.8
6.00	15.2	11.4	9.2	8.0	6.6	4.5	3.9
4.00	10.2	9.7	8.0	6.1	4.8	3.3	3.4
2.00	5.1	7.6	6.9	4.9	3.8	2.9	3.0
1.00	2.5	5.7	6.1	4.3	3.3	2.2	2.8
0.50	1.3	5.1	5.2	3.2	2.3	2.1	2.2
0.25	0.6	1.5	2.3	0.4	0.3	-0.8	0.0
0.00	0.0	0.1	-0.8	-2.6	-3.6	-4.2	-4.1
		11:20	11:30	11:40	11:50	12:00	12:10
46.00	116.8	-24.9	-27.7	-32.2	-32.2	-33.1	-32.6
45.50	115.6	-15.6	-20.0	-23.1	-23.1	-24.4	-25.9
45.00	114.3	-13.7	-18.5	-21.7	-21.8	-23.5	-24.1
44.00	111.8	-11.6	-17.3	-21.1	-21.8	-23.1	-23.7
42.00	106.7	4.8	4.1	-18.3	-17.6	-18.3	-19.4
38.00	96.5	4.7	3.8	3.1	2.1	0.9	-0.3
34.00	86.4	4.2	3.2	2.1	1.1	0.4	-1.1
30.00	76.2	4.1	3.0	1.9	0.6	-0.4	-1.7
26.00	66.0	4.1	2.9	1.7	0.4	-1.0	-2.5
22.00	55.9	4.1	2.9	1.6	0.2	-1.4	-2.8
18.00	45.7	4.2	2.8	1.6	0.1	-1.7	-3.0
14.00	35.6	3.9	2.7	1.3	-0.3	-2.3	-3.6
10.00	25.4	3.4	2.2	0.9	-0.6	-2.8	-4.2
8.00	20.3	2.8	1.8	0.6	-0.8	-3.0	-4.5
6.00	15.2	2.4	0.6	-0.8	-1.7	-4.0	-5.8
4.00	10.2	2.2	-0.7	-2.4	-4.2	-5.9	-6.5
2.00	5.1	2.0	-1.1	-3.2	-6.5	-7.2	-7.1
1.00	2.5	1.9	-1.9	-4.0	-8.9	-8.8	-7.4
0.50	1.3	1.6	-2.2	-4.5	-9.9	-10.2	-7.9
0.25	0.6	-0.5	-4.5	-8.3	-13.6	-13.1	-10.6
0.00	0.0	-4.3	-8.3	-10.5	-13.8	-14.2	-13.0

TABLE 12A (CONTINUED)

TANK 1 TEMPERATURE DISTRIBUTION, C

MARCH 9, 1983

T/C HEIGHT		PACIFIC DAYLIGHT TIME					
IN	CM	12:20	12:30	12:40	12:50	13:00	13:10
46.00	116.8	-32.8	-33.1	-33.6	-33.7	-34.5	-36.3
45.50	115.6	-24.1	-24.6	-24.9	-25.8	-26.7	-28.0
45.00	114.3	-23.4	-23.8	-24.1	-24.6	-25.6	-27.3
44.00	111.8	-23.9	-24.3	-24.7	-25.2	-26.5	-28.0
42.00	106.7	-18.4	-19.9	-20.8	-21.8	-22.9	-24.5
38.00	96.5	-16.6	-19.1	-19.8	-20.8	-21.7	-23.0
34.00	86.4	-2.7	-4.4	-5.7	-9.0	-20.3	-22.3
30.00	76.2	-3.1	-4.9	-6.1	-7.0	-8.2	-9.8
26.00	66.0	-3.6	-5.3	-6.5	-7.5	-8.7	-10.3
22.00	55.9	-3.8	-5.2	-6.5	-7.6	-8.9	-10.5
18.00	45.7	-4.0	-5.3	-6.6	-7.7	-9.3	-10.8
14.00	35.6	-4.4	-5.8	-7.0	-8.2	-9.8	-11.2
10.00	25.4	-5.0	-6.2	-7.3	-8.7	-10.0	-11.6
8.00	20.3	-5.1	-6.6	-7.6	-8.9	-10.2	-12.1
6.00	15.2	-6.5	-7.1	-8.5	-10.0	-11.3	-12.7
4.00	10.2	-7.5	-7.4	-8.9	-10.8	-12.1	-13.1
2.00	5.1	-7.8	-7.7	-9.0	-11.2	-12.2	-13.4
1.00	2.5	-8.3	-7.9	-9.1	-11.3	-12.8	-13.6
0.50	1.3	-8.8	-8.1	-9.4	-11.9	-12.8	-13.9
0.25	0.6	-11.6	-10.1	-11.8	-14.1	-15.9	-16.0
0.00	0.0	-13.7	-13.0	-14.2	-16.8	-17.9	-18.4
		13:16:45	13:30	13:40	13:50	14:00	14:10
46.00	116.8	-36.6	-37.3	-37.6	-39.7	-36.3	-36.5
45.50	115.6	-29.5	-31.2	-32.4	-33.7	-33.1	-32.9
45.00	114.3	-28.5	-30.5	-31.1	-33.3	-32.6	-31.9
44.00	111.8	-29.3	-31.4	-31.7	-33.9	-33.1	-31.9
42.00	106.7	-25.9	-28.4	-28.9	-31.4	-31.1	-30.3
38.00	96.5	-24.3	-27.0	-27.4	-29.9	-29.5	-29.1
34.00	86.4	-23.7	-26.7	-27.1	-29.0	-28.7	-28.0
30.00	76.2	-10.7	-14.1	-24.0	-27.9	-28.0	-27.8
26.00	66.0	-10.9	-12.4	-13.4	-15.3	-16.8	-22.4
22.00	55.9	-10.9	-12.6	-13.5	-15.2	-16.5	-17.0
18.00	45.7	-11.0	-12.7	-13.4	-15.4	-16.6	-17.2
14.00	35.6	-11.4	-12.8	-13.6	-15.6	-16.9	-17.4
10.00	25.4	-11.8	-13.2	-13.9	-15.9	-17.0	-17.7
8.00	20.3	-12.0	-13.6	-14.0	-16.0	-17.1	-17.9
6.00	15.2	-13.0	-14.4	-14.2	-17.1	-17.2	-18.3
4.00	10.2	-13.7	-14.8	-14.4	-17.6	-17.4	-18.6
2.00	5.1	-13.9	-14.9	-14.8	-17.9	-17.5	-19.0
1.00	2.5	-14.2	-15.2	-15.0	-18.4	-17.7	-19.5
0.50	1.3	-15.0	-15.3	-15.4	-18.9	-17.7	-19.8
0.25	0.6	-17.3	-16.7	-18.2	-21.9	-19.4	-22.5
0.00	0.0	-19.3	-19.9	-19.3	-23.0	-20.5	-22.9

TABLE 12A (CONTINUED)

TANK 1 TEMPERATURE DISTRIBUTION, C

MAR H 9, 1983

T/C HEIGHT		PACIFIC DAYLIGHT TIME					
IN	CM	14:20	14:30	14:40	14:50	15:00	15:10
46.00	116.8	-37.6	-37.5	-35.6	-36.3	-35.4	-34.5
45.50	115.6	-34.1	-34.4	-34.0	-33.8	-33.9	-32.4
45.00	114.3	-33.4	-33.4	-32.6	-33.5	-33.5	-32.3
44.00	111.8	-33.4	-33.4	-32.3	-33.6	-33.5	-32.5
42.00	106.7	-31.9	-31.6	-30.4	-31.8	-31.4	-31.0
38.00	96.5	-30.7	-30.5	-29.7	-31.2	-30.8	-30.6
34.00	86.4	-29.9	-29.5	-28.7	-30.3	-30.0	-29.8
30.00	76.2	-29.3	-29.0	-28.0	-29.8	-29.4	-29.1
26.00	66.0	-28.8	-28.7	-27.6	-29.3	-29.0	-28.9
22.00	55.9	-18.8	-19.5	-20.1	-28.2	-28.7	-28.6
18.00	45.7	-19.0	-19.6	-19.5	-21.3	-21.9	-27.4
14.00	35.6	-19.1	-19.8	-19.5	-21.6	-22.2	-22.9
10.00	25.4	-19.3	-19.8	-19.7	-21.8	-22.4	-23.0
8.00	20.3	-19.5	-20.0	-19.9	-22.0	-22.6	-23.1
6.00	15.2	-19.6	-20.2	-20.1	-22.0	-22.8	-23.2
4.00	10.2	-19.8	-20.6	-20.2	-22.0	-22.8	-23.2
2.00	5.1	-20.3	-20.9	-20.7	-22.5	-23.2	-23.4
1.00	2.5	-20.5	-21.6	-21.3	-22.8	-23.2	-23.4
0.50	1.3	-20.8	-22.1	-21.8	-23.3	-23.5	-23.5
0.25	0.6	-23.5	-23.8	-24.1	-25.4	-25.3	-25.4
0.00	0.0	-24.2	-25.0	-24.2	-25.4	-25.8	-25.3
		15:20	15:30	15:40	15:50	16:00	16:10
46.00	116.8	-32.8	-34.3	-36.1	-36.2	-36.9	-36.4
45.50	115.6	-31.8	-32.0	-33.6	-34.1	-34.6	-34.2
45.00	114.3	-31.2	-31.9	-33.3	-33.6	-34.4	-34.1
44.00	111.8	-31.0	-32.0	-33.2	-33.7	-34.5	-34.2
42.00	106.7	-29.5	-30.5	-31.1	-32.0	-32.6	-32.8
38.00	96.5	-28.9	-30.0	-30.7	-31.2	-32.2	-32.4
34.00	86.4	-28.7	-29.6	-30.4	-30.8	-32.0	-32.1
30.00	76.2	-28.0	-29.2	-30.1	-30.5	-31.7	-31.8
26.00	66.0	-27.9	-29.0	-30.0	-30.6	-31.9	-31.9
22.00	55.9	-27.6	-28.9	-30.2	-30.8	-32.0	-31.9
18.00	45.7	-27.0	-28.4	-30.1	-30.7	-31.9	-31.8
14.00	35.6	-22.6	-26.4	-29.9	-30.6	-31.9	-31.7
10.00	25.4	-22.7	-24.1	-24.4	-29.2	-30.1	-28.7
8.00	20.3	-22.8	-24.1	-24.6	-25.1	-26.0	-27.1
6.00	15.2	-23.0	-24.3	-24.6	-25.1	-26.1	-27.3
4.00	10.2	-22.9	-24.3	-24.8	-25.1	-26.2	-27.3
2.00	5.1	-23.1	-24.4	-24.9	-25.3	-26.3	-27.4
1.00	2.5	-23.0	-24.3	-24.8	-25.2	-26.2	-27.3
0.50	1.3	-23.1	-24.7	-24.9	-25.2	-26.7	-27.4
0.25	0.6	-24.2	-26.0	-26.8	-26.9	-28.2	-29.0
0.00	0.0	-24.3	-26.1	-27.2	-27.3	-28.4	-28.9

TABLE 12A (CONCLUDED)

TANK 1 TEMPERATURE DISTRIBUTION, C

MARCH 9, 1983

T/C HEIGHT		PACIFIC DAYLIGHT TIME					
IN	CM	16:20	16:30	16:40	16:50	17:00	17:10
46.00	116.8	-36.2	-36.0	-34.6	-32.8	-0.5	11.0
45.50	115.6	-33.8	-33.9	-32.7	-30.8	-4.8	8.5
45.00	114.3	-33.8	-33.9	-32.7	-30.9	-7.7	7.5
44.00	111.8	-34.1	-34.2	-33.3	-31.5	-10.9	5.9
42.00	106.7	-33.0	-33.2	-32.7	-31.0	-15.2	-2.6
38.00	96.5	-32.7	-33.1	-32.7	-30.9	-16.2	-4.8
34.00	86.4	-32.5	-32.8	-32.6	-30.8	-17.1	-6.8
30.00	76.2	-32.2	-32.6	-32.3	-30.7	-18.5	-8.9
26.00	66.0	-32.2	-32.7	-32.2	-30.3	-19.4	-10.5
22.00	55.9	-32.3	-32.8	-32.3	-30.0	-19.2	-11.7
18.00	45.7	-32.2	-32.7	-32.2	-30.0	-20.7	-13.1
14.00	35.6	-32.2	-32.8	-32.2	-30.1	-22.7	-16.1
10.00	25.4	-28.7	-28.1	-31.0	-30.0	-24.0	-16.5
8.00	20.3	-27.8	-28.4	-28.8	-29.5	-25.9	-16.7
6.00	15.2	-27.9	-28.9	-29.1	-29.5	-26.1	-16.6
4.00	10.2	-28.1	-29.0	-29.3	-29.6	-26.4	-16.7
2.00	5.1	-28.0	-29.2	-29.3	-29.5	-26.6	-17.2
1.00	2.5	-28.0	-29.1	-29.5	-29.5	-26.5	-17.0
0.50	1.3	-28.4	-29.2	-29.5	-29.3	-26.6	-16.7
0.25	0.6	-29.5	-30.6	-30.2	-29.7	-26.8	-17.1
0.00	0.0	-29.5	-30.3	-29.9	-29.5	-17.6	-12.0
		17:20	17:30	17:40	17:50		
46.00	116.8	8.2	15.7	15.4	17.4		
45.50	115.6	7.0	14.4	15.0	16.2		
45.00	114.3	5.9	12.9	14.1	15.5		
44.00	111.8	5.4	11.9	13.7	15.3		
42.00	106.7	3.5	7.8	10.7	13.2		
38.00	96.5	2.0	6.2	9.5	12.0		
34.00	86.4	0.8	4.7	8.0	10.7		
30.00	76.2	-1.2	3.0	6.5	9.4		
26.00	66.0	-2.6	1.8	4.9	8.2		
22.00	55.9	-3.7	0.2	3.8	7.1		
18.00	45.7	-5.4	-1.8	1.9	5.2		
14.00	35.6	-8.2	-5.1	-0.9	2.8		
10.00	25.4	-12.1	-6.8	-2.6	0.8		
8.00	20.3	-12.0	-6.7	-3.0	0.9		
6.00	15.2	-12.0	-6.8	-3.0	0.8		
4.00	10.2	-12.1	-6.8	-3.0	0.9		
2.00	5.1	-12.5	-7.1	-3.3	0.7		
1.00	2.5	-12.5	-7.0	-3.2	0.6		
0.50	1.3	-12.4	-6.9	-3.0	0.7		
0.25	0.6	-12.7	-7.2	-3.3	0.5		
0.00	0.0	-8.3	-3.1	0.8	2.4		

TABLE 12B

TANK 2R TEMPERATURE DISTRIBUTION, C

MARCH 9, 1983

T/C HEIGHT		PACIFIC DAYLIGHT TIME					
IN	CM	10:20	10:30	10:40	10:50	11:00	11:10
-----	-----	-----	-----	-----	-----	-----	-----
TOP SKIN		-13.	-18.	-20.	-21.	-23.	-24.
22.00	55.9	-2.7	-8.7	-11.6	-13.6	-15.3	-15.2
21.50	54.6	9.1	2.4	-1.7	-4.1	-3.1	-6.7
21.00	53.3	10.0	7.6	4.8	2.2	0.5	-1.7
20.00	50.8	10.2	8.1	5.7	3.2	0.9	-0.3
18.00	45.7	9.9	8.0	5.5	3.0	0.8	-0.5
14.00	35.6	10.1	8.1	5.6	3.0	0.8	-0.4
10.00	25.4	10.0	7.7	5.2	2.7	0.3	-0.7
8.00	20.3	9.7	7.4	5.0	2.4	0.0	-1.2
6.00	15.2	9.8	7.4	4.9	2.3	-0.2	-1.6
4.00	10.2	9.2	6.6	3.9	1.4	-1.5	-3.1
2.00	5.1	6.9	4.5	1.8	-0.4	-2.7	-3.7
1.00	2.5	3.9	2.4	-0.7	0.0	-3.9	-3.9
0.50	1.3	1.3	-0.7	-3.6	-5.9	-5.4	-4.3
0.25	0.6	0.4	-1.3	-4.4	-6.6	-6.3	-5.5
0.00	0.0	-5.2	-8.7	-11.1	-13.1	-14.5	-14.1
BOTTOM SKIN		-16.	-22.	-25.	-26.	-28.	-29.
		11:20	11:30	11:40	11:50	12:00	12:10
		-----	-----	-----	-----	-----	-----
TOP SKIN		-25.	-28.	-29.	-30.	-31.	-30.
22.00	55.9	-18.9	-22.6	-24.3	-25.6	-26.4	-27.5
21.50	54.6	-10.7	-14.4	-16.0	-17.7	-19.1	-20.3
21.00	53.3	-6.2	-9.2	-12.4	-14.9	-15.5	-16.7
20.00	50.8	-4.8	-6.7	-8.7	-10.1	-11.5	-13.5
18.00	45.7	-4.8	-6.7	-8.7	-10.3	-11.8	-13.5
14.00	35.6	-4.5	-6.6	-8.5	-10.1	-11.8	-13.4
10.00	25.4	-4.7	-6.8	-8.8	-10.6	-12.3	-14.0
8.00	20.3	-4.9	-7.1	-9.1	-10.9	-12.6	-14.4
6.00	15.2	-5.0	-7.3	-9.4	-11.0	-13.0	-14.6
4.00	10.2	-6.2	-8.5	-10.4	-12.2	-13.9	-15.6
2.00	5.1	-6.5	-9.7	-11.8	-13.7	-15.2	-16.6
1.00	2.5	-6.9	-11.4	-14.9	-16.8	-17.2	-18.3
0.50	1.3	-8.0	-13.2	-17.2	-19.4	-19.1	-19.9
0.25	0.6	-8.4	-14.2	-17.8	-20.0	-20.1	-20.3
0.00	0.0	-16.0	-19.9	-22.3	-24.3	-25.3	-25.3
BOTTOM SKIN		-30.	-33.	-34.	-34.	-35.	-37.

TABLE 12B (CONTINUED)

TANK 2R TEMPERATURE DISTRIBUTION, C

MARCH 9, 1983

T/C HEIGHT		PACIFIC DAYLIGHT TIME					
IN	CM	12:20	12:30	12:40	12:50	13:00	13:10
-----	-----	-----	-----	-----	-----	-----	-----
TOP SKIN		-32.	-32.	-32.	-33.	-34.	-35.
22.00	55.9	-28.4	-29.4	-30.5	-32.2	-32.8	-34.3
21.50	54.6	-21.9	-23.2	-24.6	-26.6	-27.6	-29.2
21.00	53.3	-17.9	-20.9	-22.6	-25.0	-25.4	-27.4
20.00	50.8	-15.5	-17.7	-19.3	-20.1	-21.1	-23.1
18.00	45.7	-15.5	-17.6	-19.3	-20.1	-21.2	-23.1
14.00	35.6	-15.4	-17.3	-19.0	-19.7	-21.0	-23.1
10.00	25.4	-15.7	-17.5	-19.1	-19.9	-21.3	-23.0
8.00	20.3	-16.0	-17.7	-19.3	-20.2	-21.4	-23.2
6.00	15.2	-16.3	-18.0	-19.5	-20.6	-21.7	-23.5
4.00	10.2	-17.4	-18.8	-20.2	-21.4	-22.6	-24.2
2.00	5.1	-18.1	-18.7	-20.4	-21.8	-23.2	-24.1
1.00	2.5	-19.2	-18.8	-20.8	-22.6	-23.4	-24.4
0.50	1.3	-20.6	-19.2	-21.8	-24.0	-24.2	-25.1
0.25	0.6	-21.1	-19.4	-22.1	-24.6	-25.0	-25.2
0.00	0.0	-26.4	-25.6	-27.1	-29.0	-29.9	-30.4
BOTTOM SKIN		-36.	-37.	-37.	-39.	-39.	-40.
		13:16:45	13:30	13:40	13:50	14:00	14:10
		-----	-----	-----	-----	-----	-----
TOP SKIN		-36.	-36.	-36.	-38.	-32.	-35.
22.00	55.9	-35.6	-36.1	-36.3	-38.7	-35.1	-35.9
21.50	54.6	-30.6	-31.4	-32.0	-34.4	-32.7	-33.2
21.00	53.3	-29.2	-29.6	-30.8	-33.1	-32.0	-32.2
20.00	50.8	-23.7	-25.2	-25.6	-28.0	-28.7	-28.5
18.00	45.7	-23.6	-25.2	-25.7	-28.0	-28.6	-28.7
14.00	35.6	-23.3	-25.0	-25.2	-27.6	-28.3	-28.2
10.00	25.4	-23.5	-25.1	-25.2	-27.7	-28.4	-28.2
8.00	20.3	-23.7	-25.5	-25.5	-27.9	-28.5	-28.4
6.00	15.2	-23.9	-25.7	-25.8	-28.0	-28.6	-28.6
4.00	10.2	-24.7	-26.1	-26.1	-28.7	-28.8	-29.0
2.00	5.1	-24.7	-26.0	-26.3	-28.6	-28.5	-29.2
1.00	2.5	-24.9	-26.1	-26.1	-28.6	-28.6	-29.3
0.50	1.3	-25.7	-26.3	-26.4	-29.0	-28.6	-30.2
0.25	0.6	-26.3	-26.5	-27.4	-29.4	-28.9	-30.8
0.00	0.0	-31.3	-31.4	-31.9	-34.1	-30.5	-32.8
BOTTOM SKIN		-41.	-42.	-42.	-44.	-37.	-39.

TABLE 12B (CONTINUED)

TANK 2R TEMPERATURE DISTRIBUTION, C

MARCH 9, 1983

T/C HEIGHT		PACIFIC DAYLIGHT TIME					
IN	CM	14:20	14:30	14:40	14:50	15:00	15:10
-----	-----	-----	-----	-----	-----	-----	-----
TOP SKIN		-35.	-36.	-34.	-34.	-34.	-32.
22.00	55.9	-36.7	-36.6	-34.9	-36.1	-36.1	-35.1
21.50	54.6	-34.2	-34.4	-33.5	-34.4	-34.5	-34.1
21.00	53.3	-33.4	-33.4	-32.7	-33.7	-33.9	-33.7
20.00	50.8	-30.2	-30.2	-29.1	-31.5	-31.9	-32.0
18.00	45.7	-30.2	-30.2	-29.4	-31.5	-31.8	-32.0
14.00	35.6	-29.8	-29.9	-28.9	-31.3	-31.5	-31.8
10.00	25.4	-29.9	-30.0	-29.0	-31.3	-31.6	-31.9
8.00	20.3	-30.1	-30.1	-29.3	-31.4	-31.7	-32.0
6.00	15.2	-30.1	-30.2	-29.7	-31.7	-31.9	-32.1
4.00	10.2	-30.6	-30.8	-30.1	-32.0	-32.2	-32.2
2.00	5.1	-30.6	-31.1	-30.8	-31.9	-32.0	-32.0
1.00	2.5	-30.8	-31.4	-30.8	-31.9	-32.1	-32.0
0.50	1.3	-31.2	-32.1	-31.4	-32.2	-32.3	-32.1
0.25	0.6	-31.5	-32.3	-32.4	-32.3	-32.4	-32.2
0.00	0.0	-33.6	-34.1	-33.0	-33.2	-33.4	-32.2
BOTTOM SKIN		-40.	-39.	-37.	-37.	-38.	-36.
		15:20	15:30	15:40	15:50	16:00	16:10
		-----	-----	-----	-----	-----	-----
TOP SKIN		-31.	-33.	-35.	-35.	-35.	-34.
22.00	55.9	-33.3	-35.6	-37.2	-37.2	-37.7	-37.0
21.50	54.6	-33.0	-34.3	-35.5	-35.6	-36.3	-35.9
21.00	53.3	-32.3	-34.0	-35.0	-35.2	-35.7	-35.3
20.00	50.8	-30.8	-32.5	-32.7	-32.9	-33.4	-33.4
18.00	45.7	-30.9	-32.5	-32.7	-32.8	-33.3	-33.4
14.00	35.6	-30.8	-32.2	-32.4	-32.5	-33.0	-33.1
10.00	25.4	-30.6	-32.2	-32.5	-32.6	-33.0	-33.1
8.00	20.3	-30.8	-32.3	-32.5	-32.7	-33.1	-33.3
6.00	15.2	-31.1	-32.4	-32.7	-32.8	-33.2	-33.3
4.00	10.2	-31.4	-32.4	-32.7	-32.9	-33.3	-33.5
2.00	5.1	-31.3	-32.4	-32.6	-32.8	-33.2	-33.3
1.00	2.5	-31.0	-32.3	-32.6	-32.8	-33.2	-33.3
0.50	1.3	-31.1	-32.4	-32.8	-32.8	-33.5	-33.4
0.25	0.6	-32.1	-32.5	-32.9	-33.1	-33.6	-33.5
0.00	0.0	-31.6	-32.9	-33.9	-34.1	-34.4	-33.9
BOTTOM SKIN		-35.	-37.	-39.	-39.	-40.	-38.

TABLE 12B (CONCLUDED)

TANK 2R TEMPERATURE DISTRIBUTION, C

MARCH 9, 1983

T/C HEIGHT		PACIFIC DAYLIGHT TIME					
IN	CM	16:20	16:30	16:40	16:50	17:00	17:10
-----	-----	-----	-----	-----	-----	-----	-----
TOP SKIN		-35.	-35.	-34.	-32.	-1.	-3.
22.00	55.9	-37.8	-38.0	-37.0	-36.5	2.6	11.9
21.50	54.6	-36.2	-36.7	-36.1	-36.4	-6.1	9.4
21.00	53.3	-35.7	-36.3	-35.7	-36.2	-6.2	8.9
20.00	50.8	-33.6	-34.0	-34.0	-36.1	-8.4	7.7
18.00	45.7	-33.6	-33.9	-34.0	-35.3	-14.2	0.2
14.00	35.6	-33.4	-33.5	-33.7	-33.4	-23.8	-11.6
10.00	25.4	-33.4	-33.6	-33.8	-33.4	-28.7	-19.3
8.00	20.3	-33.5	-33.7	-33.9	-33.6	-29.0	-19.9
6.00	15.2	-33.6	-33.8	-33.9	-33.6	-29.4	-20.0
4.00	10.2	-33.7	-33.9	-34.0	-33.7	-29.5	-19.8
2.00	5.1	-33.6	-33.8	-33.9	-33.5	-29.0	-19.8
1.00	2.5	-33.6	-33.8	-33.9	-33.5	-28.7	-19.3
0.50	1.3	-33.7	-34.0	-33.8	-33.4	-28.7	-19.5
0.25	0.6	-33.9	-34.0	-34.0	-33.6	-28.6	-20.1
0.00	0.0	-34.6	-34.7	-33.9	-32.8	-16.5	-13.5
BOTTOM SKIN		-40.	-39.	-38.	-37.	10.	11.
		17:20	17:30	17:40	17:50		
		-----	-----	-----	-----		
TOP SKIN		3.	6.	11.	18.		
22.00	55.9	8.6	17.0	15.6	17.6		
21.50	54.6	5.4	14.8	15.3	16.4		
21.00	53.3	5.4	14.7	15.2	16.4		
20.00	50.8	4.6	13.9	14.9	16.2		
18.00	45.7	1.4	9.7	12.7	14.8		
14.00	35.6	-5.0	2.6	8.2	12.4		
10.00	25.4	-9.6	-2.8	4.5	11.1		
8.00	20.3	-11.3	-4.9	3.1	10.9		
6.00	15.2	-14.0	-6.8	1.9	10.9		
4.00	10.2	-13.6	-7.7	1.3	11.5		
2.00	5.1	-12.8	-6.7	2.0	12.5		
1.00	2.5	-12.8	-6.7	2.2	12.8		
0.50	1.3	-13.0	-6.7	2.1	9.7		
0.25	0.6	-13.0	-6.9	2.0	9.7		
0.00	0.0	-7.0	-3.0	5.2	13.8		
BOTTOM SKIN		12.	18.	15.	19.		

TABLE 13

BULK AND MINIMUM TEMPERATURES - TANK 1 COLD SOAK APRIL 23, 1981

TIME,		TEMPERATURE, C			
PACIFIC DAYLIGHT	CABIN GAUGE	INBOARD		OUTBOARD	
-----	-----	BULK	MINIMUM	BULK	MINIMUM
-----	-----	----	-----	----	-----
8:52	25.0				
9:00	25.0	20.6	20.1	21.4	21.0
9:02	25.0				
9:10		20.8	20.3	22.1	21.8
9:20	25.0	20.9	20.3	22.2	22.0
9:30	25.0	20.7	19.2	21.7	21.5
9:40	25.0	20.5	18.4	20.7	20.5
9:50	25.0	20.1	16.1	19.8	19.2
10:00	23.0	18.7	6.6	17.4	16.2
10:10	20.0	16.7	-1.0	14.3	12.9
10:12:20	20.0				
10:20	17.5	14.7	-3.5	10.9	9.6
10:30	13.0	12.7	-8.3	7.5	6.4
10:40	10.0	10.9	-6.2	3.1	2.8
10:50	9.0	9.5	-2.7	-1.0	-1.4
11:00	7.0	8.2	-1.9	-4.9	-5.1
11:10	3.0	6.6	-7.9	-8.9	-8.6
11:20	0.0	5.1	-9.4		
11:30	-4.0	3.8	-10.7		
11:40	-6.0	2.5	-12.3		
11:50	-6.0	1.5	-11.7		
12:00	-6.0	0.4	-12.1		
12:10	-7.0	-0.2	-9.2		
12:20	-10.0	-1.1	-10.2		
12:30	-10.0	-2.2	-11.0		
12:40	-10.5	-3.5	-15.3		
12:50	-12.0	-4.6	-16.1		
13:00	-12.5	-5.6	-18.6		
13:10	-13.0	-6.6	-19.9		
13:20	-13.0	-7.6	-20.1		
13:30	-12.0	-8.4	-20.0		
13:40	-13.0	-9.1	-21.1		
13:50	-15.0	-10.0	-21.4		
14:00	-15.0	-10.6	-20.4		
14:10	-15.0	-11.3	-21.6		
14:20	-14.0	-11.9	-22.1		
14:30	-14.0	-12.5	-22.7		
14:40	-15.0	-13.2	-23.3		

TABLE 14

BULK AND MINIMUM TEMPERATURES - TANK 2R COLD SOAK APRIL 30, 1981

TIME,		TEMPERATURE, C			
PACIFIC DAYLIGHT	CABIN GAUGE	INBOARD		OUTBOARD	
		BULK	MINIMUM	BULK	MINIMUM
8:20	27.0				
8:30	27.0				
8:40	27.0	24.4	24.0	23.6	23.3
8:50		24.5	24.0	23.8	23.5
8:55	27.0				
9:00	27.0	24.8	24.2	24.1	23.9
9:10	27.0	24.7	24.3	23.6	23.5
9:20	27.0	25.0	24.6	23.7	23.4
9:30	26.0	25.2	21.2	23.1	19.9
9:40	24.0	24.7	20.9	21.6	18.9
9:50	12.5	23.6	16.6	19.2	12.5
10:00	7.5	21.9	12.9	16.8	7.7
10:10	4.0	18.5	10.7	12.5	5.4
10:20	2.0	18.3	12.5	11.6	6.7
10:30	0.0	16.5	10.3	10.0	5.8
10:40	0.0	15.9	9.1	9.1	2.5
10:50	-1.0	15.3	7.2	8.3	3.1
11:00	-2.0	12.5	6.5	4.4	-0.1
11:10	-3.0	11.5	7.3	2.8	0.1
11:20	-4.5	10.2	5.6	1.1	-1.3
11:30	-5.5	9.0	-0.5	0.2	-7.2
11:40	-7.0	8.9	4.0	-0.1	-2.1
11:50	-8.0	8.2	5.6	-1.6	-3.1
12:00	-9.0	5.4	1.1	-4.4	-6.2
12:10	-9.0	4.6	2.6	-5.3	-6.4
12:20	-9.5	3.8	0.3	-5.9	-7.3
12:30	-9.5	3.4	-0.5	-6.1	-7.9
12:40	-9.5	2.9	-0.2	-6.2	-7.5
12:50	-9.5	2.5	0.4	-6.7	-7.1
13:00	-10.0	2.1	-1.8	-6.7	-8.5
13:10	-12.0	0.7	-3.4	-7.9	-11.2
13:20	-13.0	-2.8	-7.1	-11.2	-12.7
13:30	-14.5	-3.8	-8.1	-12.1	-13.4
13:40	-16.0	-4.5	-8.0	-12.5	-13.6
13:50	-16.5	-4.9	-6.7	-12.3	-12.8
14:00	-16.5	-4.8	-7.3	-11.6	-12.7
14:10	-16.0	-7.9	-10.0	-14.5	-14.7
14:20	-15.0	-8.2	-8.9	-14.3	-14.4
14:30	-14.5	-7.3	-7.8	-13.0	-13.6
14:40	-14.5	-10.2	-12.6	-15.3	-16.6
14:50	-15.0	-11.0	-14.2	-15.7	-19.1

TABLE 15

BULK AND MINIMUM TEMPERATURES - TANK 2R COLD SOAK

JUNE 21, 1981

TIME,		TEMPERATURE, C			
PACIFIC DAYLIGHT -----	CABIN GAUGE -----	INBOARD		OUTBOARD	
		BULK ----	MINIMUM -----	BULK ----	MINIMUM -----
7:00		29.0	28.1	27.7	27.0
7:10		28.5	28.2	27.0	26.9
7:20		28.8	28.6	27.5	27.4
7:30	30.0	28.7	28.3	27.2	26.9
7:40	28.0	28.3	22.2	26.1	19.4
7:50	23.0	27.2	17.9	24.5	17.0
7:54		28.5	18.1	25.7	18.2
8:10	12.0	25.9	18.1	21.4	17.4
8:20	8.0	24.5	15.9	19.3	12.2
8:30	5.0	21.4	10.0	15.3	6.6
8:40	2.0	20.9	11.3	14.2	5.9
8:50	0.0	18.9	11.7	11.1	6.8
9:00	0.0	17.7	5.5	9.2	1.5
9:10	-2.0	17.2	4.5	8.3	1.1
9:20	-3.0	15.8	3.6	6.7	-0.5
9:30	-5.0	14.4	3.1	4.6	-3.3
9:39		13.9	1.9	3.8	-2.5
9:40	-7.0				
9:50	-7.0	12.5	1.6	2.4	-2.9
10:00	-7.0	10.8	0.6	0.8	-5.1
10:10	-8.0	10.1	0.6	-0.2	-5.0
10:20	-9.0	10.3	0.3	-0.2	-5.3
10:30	-10.0	8.8	0.1	-1.6	-6.6
10:40	-10.0	7.7	0.6	-2.2	-5.7
10:50	-11.0	4.8	0.0	-5.6	-7.9
11:00	-12.0	5.1	0.5	-5.1	-7.5
11:10	-12.0	4.2	-2.5	-5.5	-8.1
11:20	-12.0	3.4	-0.1	-6.1	-7.5
11:25	-12.0				
11:30		2.3	-3.5	-7.0	-9.2
11:40	-13.0	0.8	-5.2	-8.1	-10.9
11:50	-14.0	-0.2	-4.4	-8.7	-11.0
12:00	-14.0	-2.0	-4.1	-9.7	-10.9
12:10		-3.2	-7.7	-10.5	-13.2
12:12	-14.0				
12:18		-4.1	-8.9	-10.8	-13.8
12:20	-16.0				
12:30	-16.0				
12:40	-16.0				
12:50	-16.0	-11.0	-13.0	-15.1	-17.2
13:00	-16.0	-12.1	-15.2	-15.3	-17.3

TABLE 16

BULK AND MINIMUM TEMPERATURES - TANK 2R COLD SOAK MARCH 9, 1983

TIME,		TEMPERATURE, C			
PACIFIC DAYLIGHT	CABIN GAUGE	INBOARD		OUTBOARD	
-----	-----	BULK -----	MINIMUM -----	BULK -----	MINIMUM -----
9:30	17				
9:40	17				
9:50	16				
10:00	17				
10:10	14				
10:20	5	12.2	1.5	9.1	0.4
10:30	-2	10.9	2.3	6.9	-1.3
10:40	-7	9.4	0.4	4.4	-4.4
10:50	-10	7.9	0.3	2.0	-6.6
11:00	-15	6.4	-0.8	-0.4	-6.3
11:10	-15	6.0	0.0	-1.5	-5.5
11:20	-17	3.7	-0.5	-5.3	-8.4
11:30	-18	2.4	-4.5	-7.7	-14.2
11:40	-20	0.9	-8.3	-9.8	-17.8
11:50	-22	-0.6	-13.6	-11.5	-20.0
12:00	-24	-2.1	-13.1	-13.0	-20.1
12:10	-25	-3.2	-10.6	-14.6	-20.3
12:20	-25	-4.6	-11.6	-16.4	-21.1
12:30	-26	-5.8	-10.1	-17.9	-19.4
12:40	-27	-7.1	-11.8	-19.6	-22.1
12:50	-28	-8.5	-14.1	-20.6	-24.6
13:00	-28	-9.9	-15.9	-21.8	-25.0
13:10	-29	-11.3	-16.0	-23.5	-25.2
13:16:45		-11.8	-17.3	-23.9	-26.3
13:20	-30				
13:30	-31	-13.4	-16.7	-25.5	-26.5
13:40	-32	-13.9	-18.2	-25.7	-27.4
13:50	-33	-16.1	-21.9	-28.1	-29.4
14:00	-33	-17.0	-19.4	-28.5	-28.9
14:10	-33	-17.8	-22.5	-28.6	-30.8
14:20	-33	-19.4	-23.5	-30.2	-31.5
14:30	-33	-20.1	-23.8	-30.4	-32.3
14:40	-33	-20.0	-24.1	-29.6	-32.4
14:50	-33	-21.9	-25.4	-31.6	-32.3
15:00	-32	-22.5	-25.3	-31.8	-32.4
15:10	-32	-23.2	-25.4	-32.0	-32.2
15:20	-32	-22.8	-24.2	-30.9	-32.1
15:30	-31	-24.3	-26.0	-32.3	-32.5
15:40	-30	-24.7	-26.8	-32.6	-32.9
15:50	-30	-25.2	-26.9	-32.7	-33.1
16:00	-30	-26.3	-28.2	-33.2	-33.6
16:10	-30	-27.3	-29.0	-33.3	-33.5
16:20	-30	-28.2	-29.5	-33.5	-33.9
16:30	-30	-28.7	-30.6	-33.8	-34.0
16:40	-30	-29.2	-30.2	-33.9	-34.0
16:50	-30	-29.5	-29.7	-34.0	-33.7

TABLE 17

FUEL TANK SIMULATOR THERMOCOUPLE DATA 7-19-84

EASTERN DAYLIGHT TIME, 11:25 START TEST

T/C	HEIGHT, CM	RAKE A	RAKE B	RAKE C	RAKE D	RAKE E
12	50.2	14.9	13.3	13.5	14.0	14.3
11	48.9	15.1	14.3	14.8	14.6	14.8
10	47.0	15.2	15.2	15.0	15.1	14.9
9	45.1	15.1	15.2	15.1	15.0	14.7
8	25.4	14.9	15.2	15.2	15.2	15.3
7	12.7	14.9	15.2	15.2	15.2	14.9
6	9.3	15.1	15.2	15.1	15.1	15.2
5	7.6	15.1	15.2	15.2	14.9	15.1
4	5.7	15.2	15.2	15.1	15.1	15.0
3	3.8	15.2	15.2	15.2	14.8	14.9
2	1.9	15.1	15.1	15.0	14.9	15.0
1	0.6	15.1	14.9	14.9	15.4	14.9

12:55

12	50.2	-8.6	-9.9	-9.0	-10.0	-8.3
11	48.9	-8.5	-8.6	-8.3	-8.5	-8.3
10	47.0	-8.3	-8.2	-8.1	-8.4	-8.2
9	45.1	-8.4	-8.0	-8.2	-8.4	-8.4
8	25.4	-8.2	-8.0	-8.0	-8.2	-7.9
7	12.7	-8.6	-8.2	-8.4	-8.2	-8.3
6	9.3	-8.4	-8.0	-8.4	-8.3	-8.3
5	7.6	-8.4	-8.4	-8.3	-8.4	-8.4
4	5.7	-8.3	-8.3	-8.6	-8.3	-8.5
3	3.8	-8.8	-9.2	-9.4	-8.8	-9.2
2	1.9	-10.8	-10.8	-10.9	-12.0	-12.4
1	0.6	-13.2	-13.4	-14.0	-11.8	-15.7

13:55

12	50.2	-19.9	-20.4	-19.6	-20.4	-18.9
11	48.9	-20.7	-19.6	-19.5	-20.2	-19.3
10	47.0	-20.0	-18.9	-19.3	-19.6	-19.4
9	45.1	-19.3	-19.2	-19.3	-19.5	-19.5
8	25.4	-19.0	-19.2	-19.2	-19.2	-19.2
7	12.7	-19.4	-19.5	-19.3	-19.3	-19.6
6	9.3	-19.5	-19.3	-19.5	-19.3	-19.3
5	7.6	-19.5	-19.3	-19.3	-19.5	-19.5
4	5.7	-19.4	-19.5	-19.7	-19.3	-19.6
3	3.8	-19.8	-20.0	-20.4	-20.8	-20.4
2	1.9	-21.0	-21.2	-21.4	-19.9	-23.0
1	0.6	-22.5	-23.1	-23.3	-20.2	-24.3

TABLE 17 (CONCLUDED)

FUEL TANK SIMULATOR THERMOCOUPLE DATA 7-19-84

EASTERN DAYLIGHT TIME, 18:05 END TEST

T/C	HEIGHT, CM	RAKE A	RAKE B	RAKE C	RAKE D	RAKE E
12	50.2	-34.2	-33.0	-34.0	-34.0	-33.4
11	48.9	-34.3	-33.8	-34.3	-34.0	-34.2
10	47.0	-34.1	-33.8	-34.4	-33.7	-34.4
9	45.1	-34.2	-34.2	-34.4	-33.8	-34.5
8	25.4	-34.1	-34.2	-34.3	-33.6	-34.4
7	12.7	-34.5	-34.4	-34.3	-33.4	-34.5
6	9.3	-34.4	-34.2	-34.2	-31.8	-34.4
5	7.6	-34.3	-34.2	-34.1	-34.2	-34.4
4	5.7	-34.1	-34.2	-34.1	-32.3	-34.5
3	3.8	-34.3	-34.2	-34.3	-30.9	-34.7
2	1.9	-34.5	-34.3	-34.5	-30.4	-34.5
1	0.6	-34.4	-34.4	-34.9	-29.8	-34.6

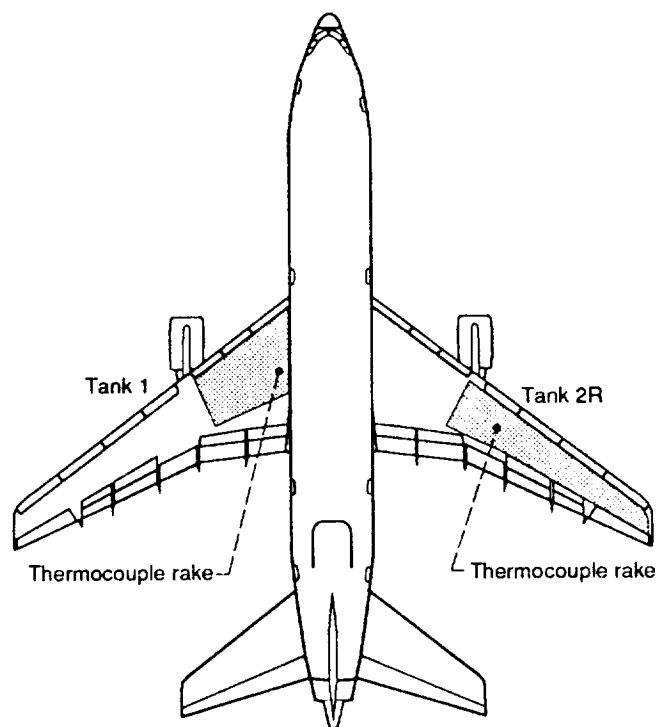


Figure 1.—L1011 wing tank and thermocouple locations.

ORIGINAL PAGE
BLACK AND WHITE PHOTOGRAPH



Figure 2.—Outboard tank 2R thermocouple rake.

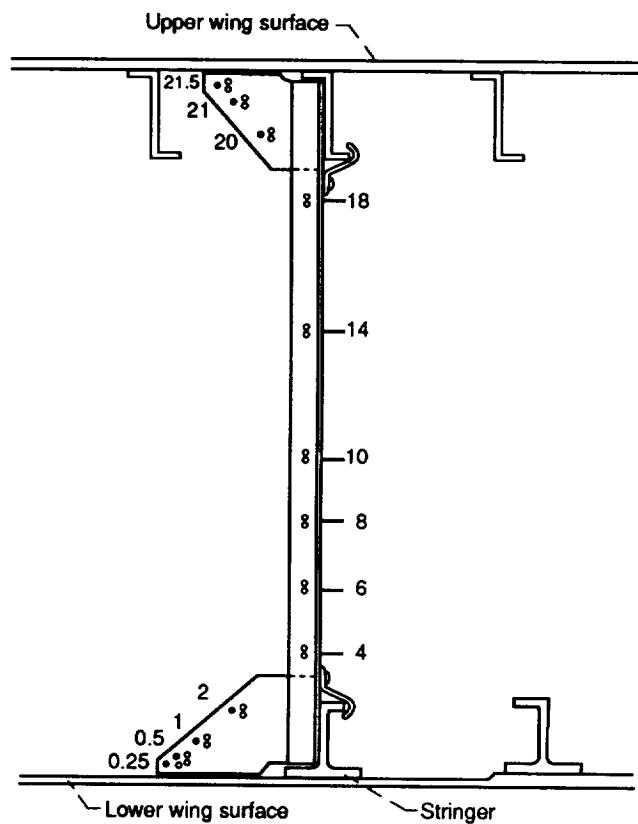


Figure 3.—Outboard tank 2R thermocouple rake mounting.

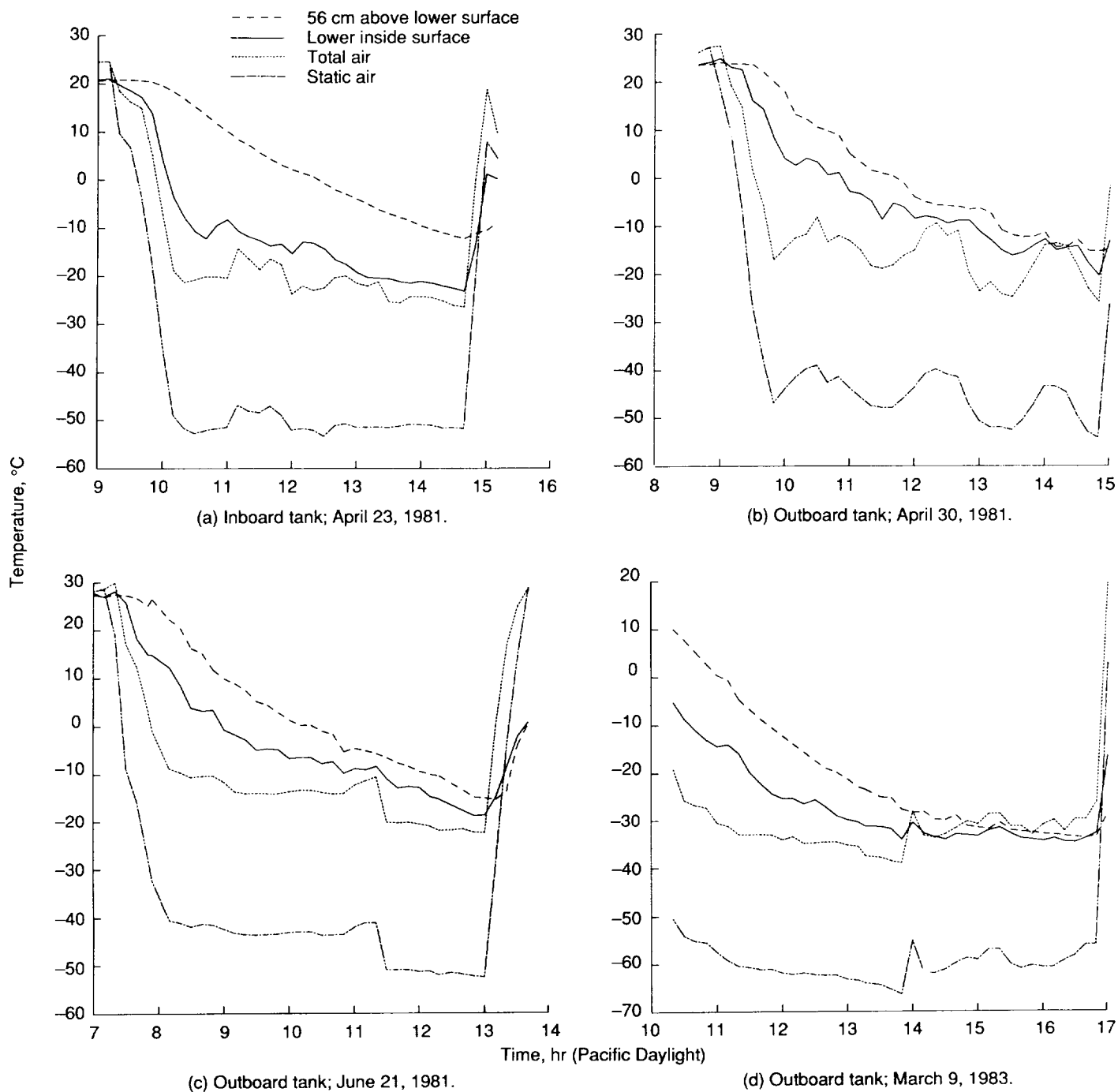
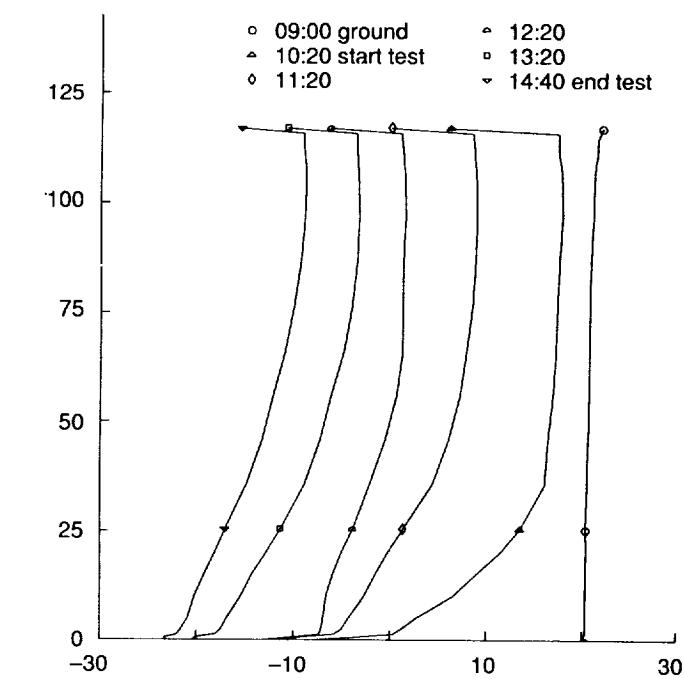
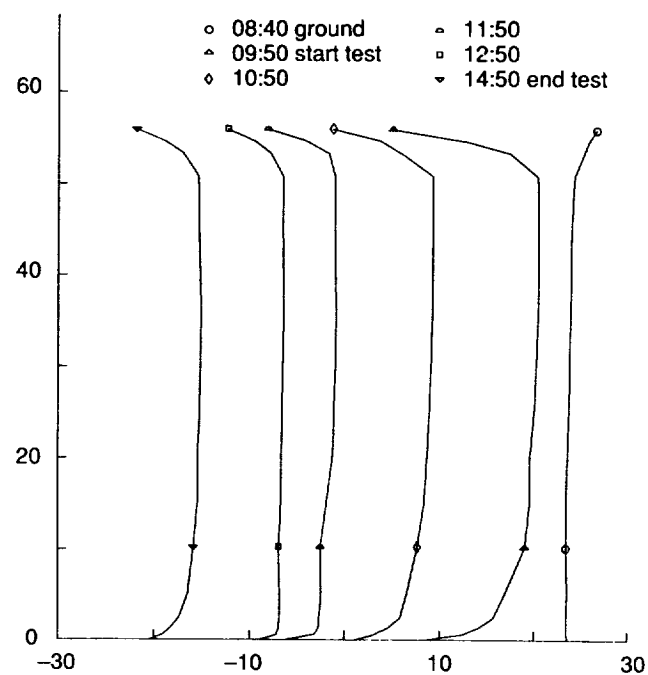


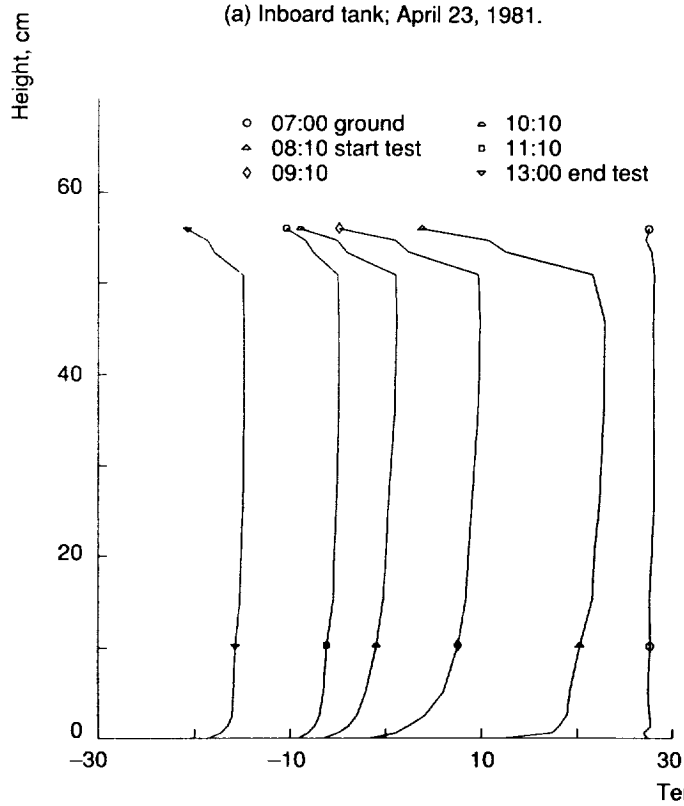
Figure 4.—Temperature histories of the fuel, surface, and ambient air.



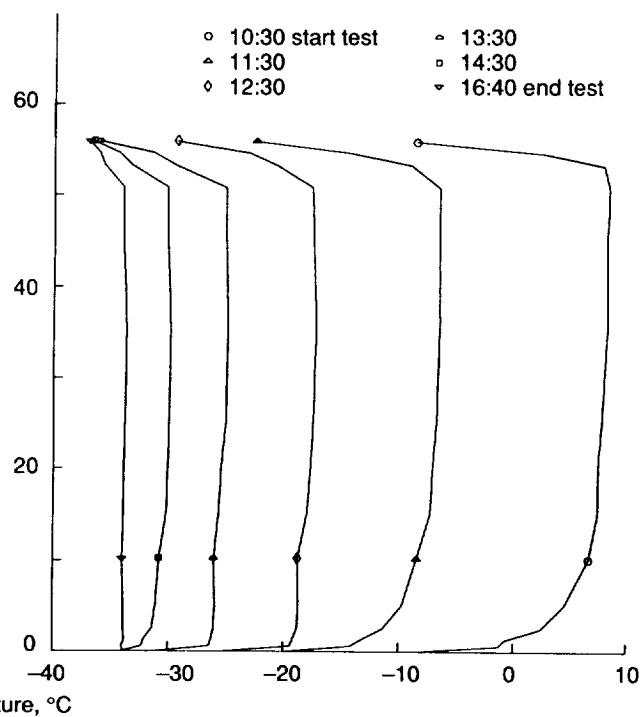
(a) Inboard tank; April 23, 1981.



(b) Outboard tank; April 30, 1981.



(c) Outboard tank; June 21, 1981.



(d) Outboard tank; March 9, 1983.

Figure 5.—Fuel temperature profiles.

ORIGINAL PAGE
BLACK AND WHITE PHOTOGRAPH

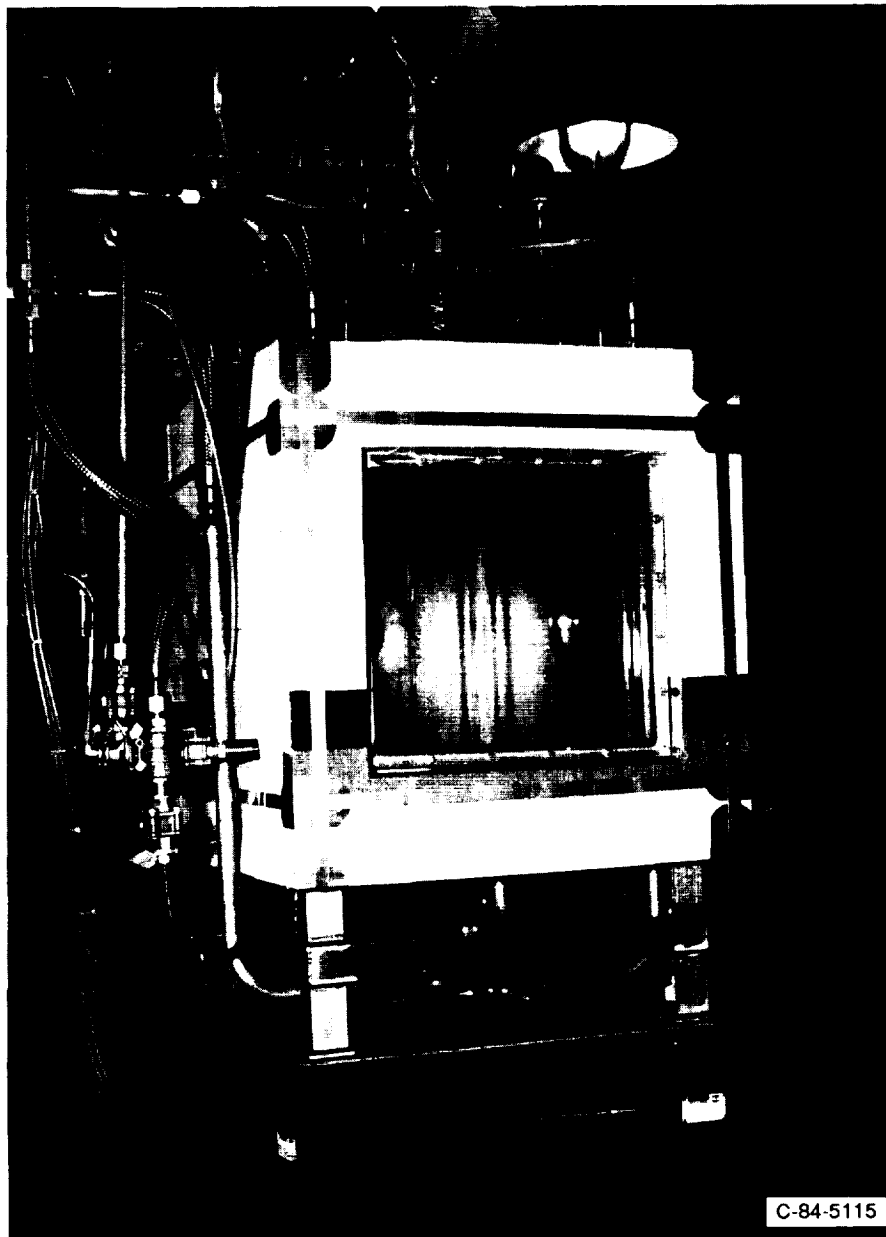


Figure 6.—NASA Lewis Research Center fuel tank simulator.

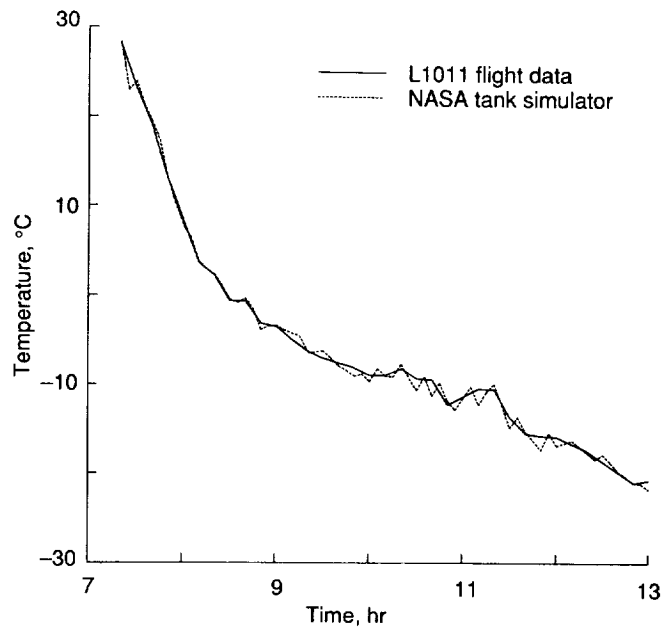


Figure 7.—L1011 outboard tank and NASA simulator upper surface temperature. Flight and simulation of June 21, 1981.

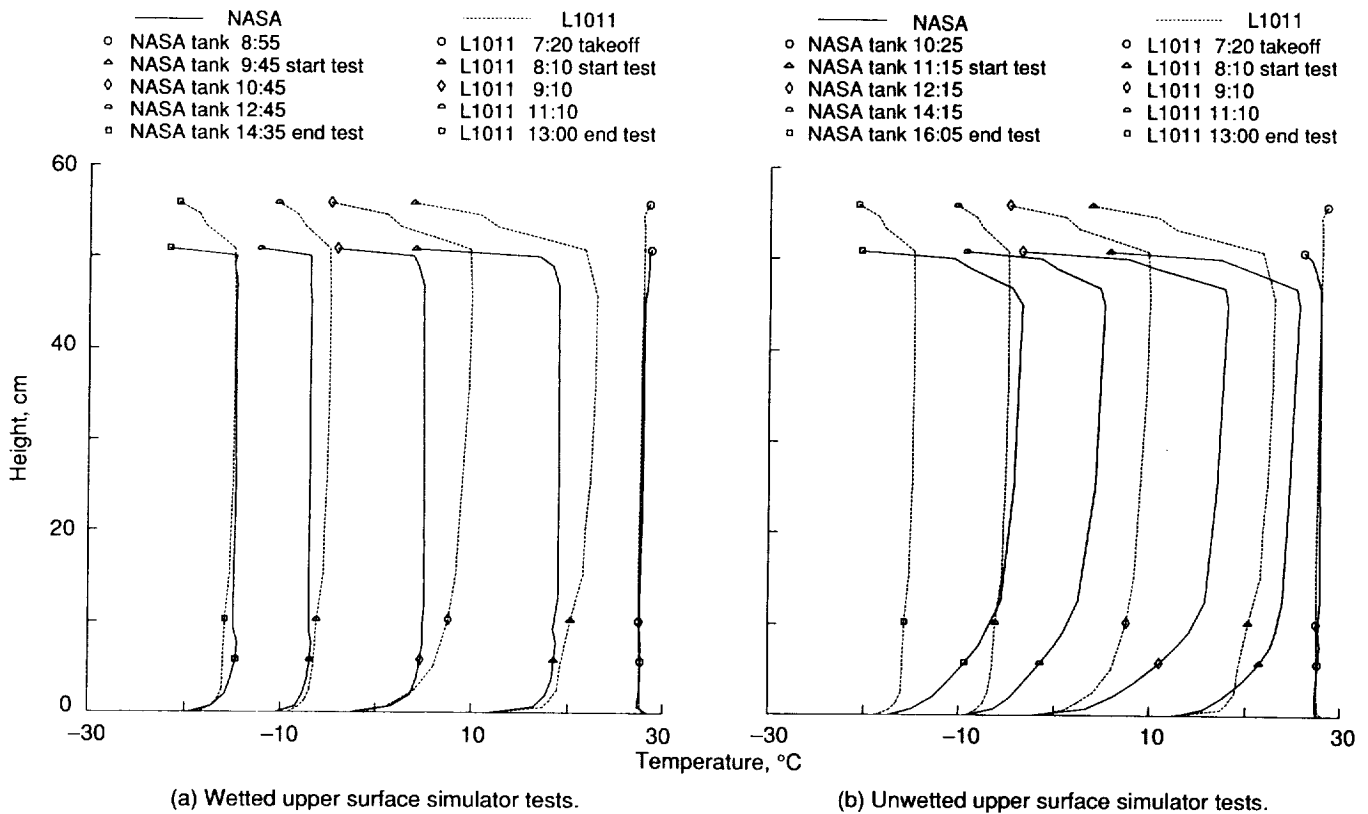


Figure 8.—Fuel temperature profiles. L1011 outboard tank and NASA simulator. Flight and simulation of June 21, 1981.

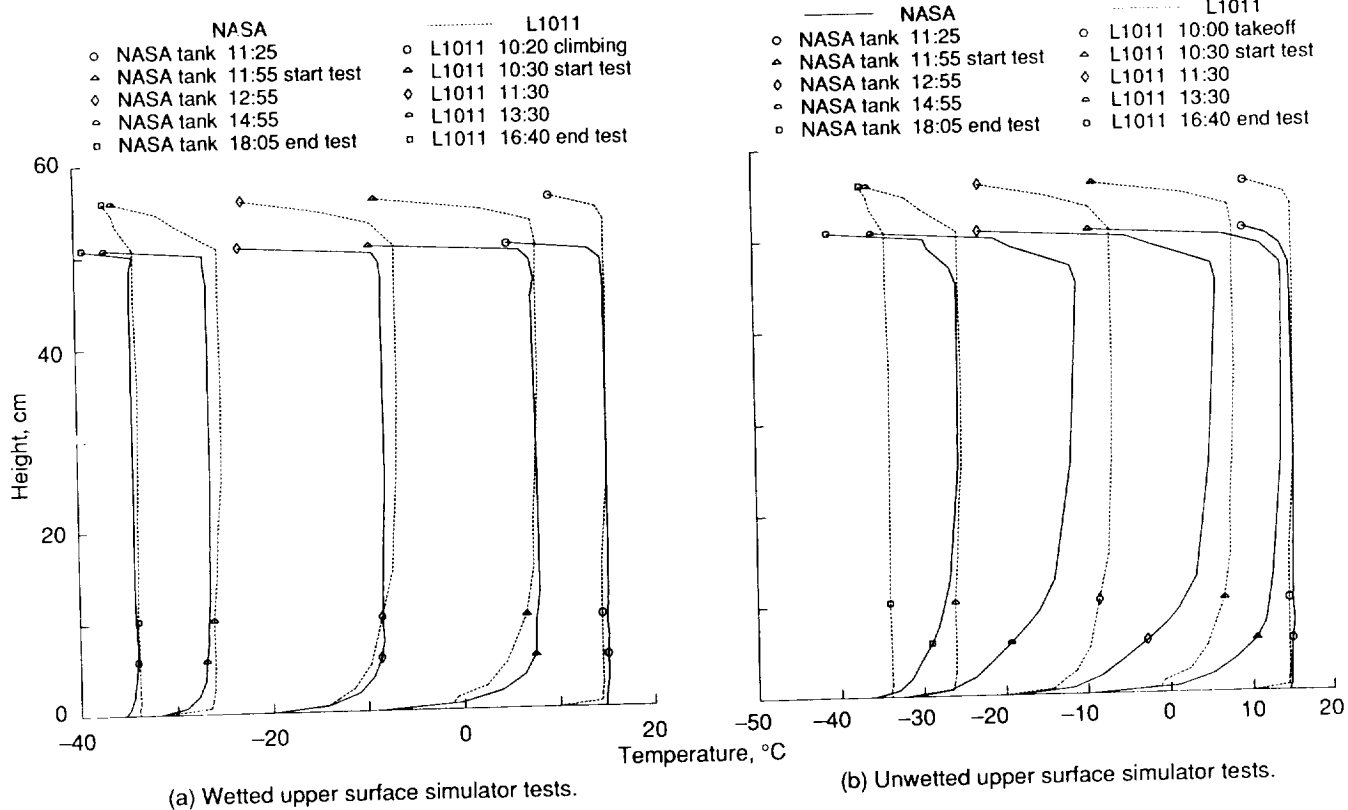


Figure 9.—Fuel temperature profiles. L1011 outboard tank and NASA simulator. Flight and simulation of March 9, 1983.

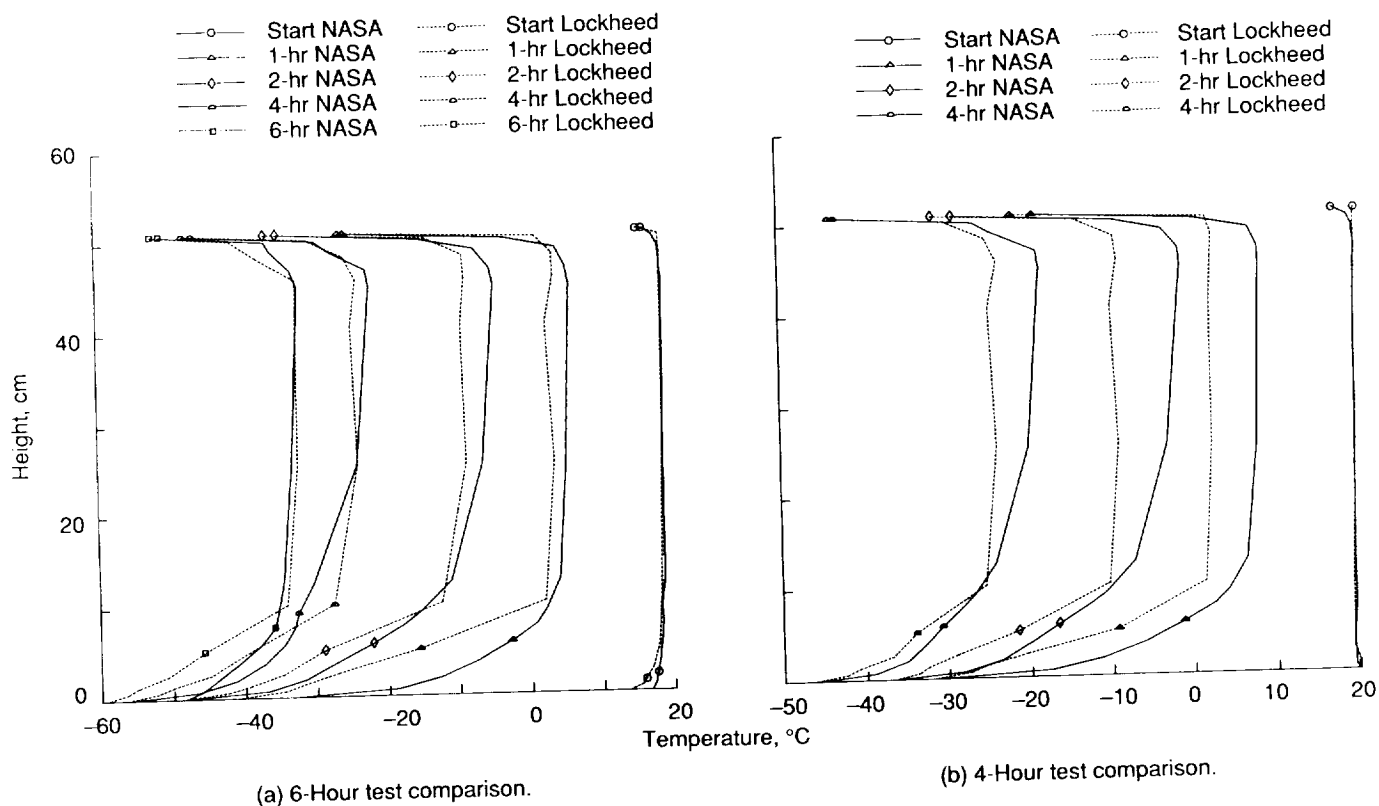


Figure 10.—Fuel temperature profiles of Lockheed and NASA simulators.

Report Documentation Page

1. Report No. NASA TM-103611		2. Government Accession No.		3. Recipient's Catalog No.	
4. Title and Subtitle In-Flight and Simulated Aircraft Fuel Temperature Measurements				5. Report Date December 1990	
				6. Performing Organization Code	
7. Author(s) Roger A. Svehla				8. Performing Organization Report No. E-5765	
				10. Work Unit No. 505-62-21	
9. Performing Organization Name and Address National Aeronautics and Space Administration Lewis Research Center Cleveland, Ohio 44135-3191				11. Contract or Grant No.	
				13. Type of Report and Period Covered Technical Memorandum	
12. Sponsoring Agency Name and Address National Aeronautics and Space Administration Washington, D.C. 20546-0001				14. Sponsoring Agency Code	
15. Supplementary Notes					
16. Abstract Fuel tank measurements from ten flights of an L1011 commercial aircraft are reported for the first time. The flights were conducted from 1981 to 1983. A thermocouple rake was installed in an inboard wing tank and another in an outboard tank. During the test periods of either 2 or 5 hr, at altitudes of 10 700 m (35 000 ft) or higher, either the inboard or the outboard tank remained full. Fuel temperature profiles generally developed in the expected manner. The bulk fuel was mixed by natural convection to a nearly uniform temperature, especially in the outboard tank, and a gradient existed at the bottom conduction zone. The data indicated that when full, the upper surface of the inboard tank was wetted and the outboard tank was unwetted. Companion NASA Lewis Research Center tests were conducted in a 0.20 m ³ (52 gal) tank simulator of the outboard tank, chilled on the top and bottom, and insulated on the sides. Even though the simulator tank had no internal components corresponding to the wing tank, temperatures agreed with the flight measurements for wetted upper surface conditions, but not for unwetted conditions. It was concluded that if boundary conditions are carefully controlled simulators are a useful way of evaluating actual flight temperatures.					
17. Key Words (Suggested by Author(s)) Aircraft fuel Jet fuel Fuel temperature Fuel freezing temperature			18. Distribution Statement Unclassified—Unlimited Subject Category 28		
19. Security Classif. (of this report) Unclassified		20. Security Classif. (of this page) Unclassified		21. No. of pages 80	
				22. Price* A05	